

## APPENDIX E. ROOM-SCALE EXPERIMENTS WITH OZONE

This appendix presents supplemental and detailed material supporting the text and display items for §4.4-4.5.

Experiments were conducted to quantify chemical reactions and the formation of secondary pollutants when cleaning products and air fresheners are used in the presence of ozone. The same three products were used for these experiments as for the small chamber experiments described in §4.2-4.3 and Appendix D: GPC-1, GPD-1, and AFR-1. The basic construct of the experiments was the following: each product was used in a realistic manner in LBNL's room-sized ( $50\text{ m}^3$ ) chamber without ozone, then in an identically scripted manner with ozone provided in chamber supply air. A complete list of experiments is provided in Table 4.7 and protocols are described in §4.4. The following paragraphs provide a brief guide to the tables and figures included in this appendix.

Tables E.1 through E.13 list the primary VOC concentrations measured in chamber air throughout the experiments; primary VOCs refer to those contained in the products and emitted during product use. GPD-1 experimental results are reported in Tables E.1 (no ozone) and E.2 (with ozone). VOC concentrations measured in experiments with GPC-1 are provided in Tables E.3-E.5 (no ozone) and E.6-E.11 (with ozone). VOC concentrations in experiments with AFR-1 are shown in Tables E.12-E.13. In most cases, samples were collected over relatively short periods (1-20 min duration) that were selected to provide resolved information about temporal VOC patterns. In all experiments with GPC-1, samples were also collected over the integrated periods of 0-30 min, 30-90 min, 90-240 min, and 240-720 min. Concentrations are presented in units of parts per billion and displayed to 2 decimal places for all values for uniformity of presentation; these should not be construed as signifying the measurement precision. In Table E.6, results are incomplete because GC-MS output files were analyzed for only a subset of VOCs. Complete data are available for the time-integrated samples from this experiment (Exp. 3F, Table E.7) and for both time-integrated and time-resolved samples for the other two experiments featuring GPC-1 use in the presence of ozone (Exps. 3G-3H, Tables E.8-E.11).

Degradation can occur on Tenax when ozone in the sample air stream encounters a collected, reactive VOC (Calogirou et al., 1996). As a result, reported concentrations of some VOCs measured in the presence of ozone are biased low owing to degradation. Based on Calogirou et al. (1996), the extent of degradation depends on the following factors: (a) concentration of ozone in the air stream, (b) reactivity of collected VOC with ozone, and (c) sample duration. Sample airflow rate may also be important. The gas phase VOC concentration and the total mass of VOC collected on the sample are also important factors in determining the relative importance of degradation.

The conditions extant in our experiments and the details of individual samples were evaluated in relation to the degradation experiments reported by Calogirou et al. (1996) to identify specific cases in which degradation is likely to have occurred. For this assessment, the analyzed VOCs were grouped according to their reactivity with ozone. Specifically, the ozone-reactivity of each VOC was evaluated in relation to the ozone-reactivity of limonene. The VOCs were grouped as follows:

- Group 0: no appreciable reactivity with ozone;
- Group 1: ozone reactivity much less than (<20%) d-limonene ( $\alpha$ -pinene);
- Group 2: ozone-reactivity similar (0.5 to 1.5 $\times$ ) to d-limonene ( $\gamma$ -terpinene, tentatively identified terpenes eluting at 26.3 and 29.4 min,  $\alpha$ -terpineol, 4-terpineol,  $\beta$ -citronellol);
- Group 3: ozone reactivity ~2 $\times$  that of limonene (linalool and linalyl acetate);

- Group 4: ozone reactive >3× that of limonene ( $\alpha$ -terpinene, terpinolene, tentatively identified terpene at 28.2 min,  $\gamma$ -terpineol,  $\alpha$ -phellandrene).

Based on Figure 1 of Calogirou et al. (1996) the following degradation effects were observed for varying ozone concentrations when sampling occurred for 10 min at 100 mL/min; degradation effects are expressed as a reduction in the measured versus the actual VOC concentration:

- Group 1: reduction of <20% up to 60 ppb;
- Group 2: 30% reduction at 30 ppb; 60% reduction at 60 ppb;
- Group 3: 60% reduction at 30 ppb; 80% reduction at 60 ppb
- Group 4: 80% reduction at 30 ppb.

Overall, little effect was seen for any compound when the ozone level was at 8 ppb. Ozone concentrations in our large chamber experiments were between 4 and 60 ppb.

From Figure 2 of Calogirou et al., it was observed that shorter sampling times (even at higher flow rates) greatly reduce degradation effects. The results presented in this figure were utilized as follows:

- Group 1: Assume no effect at sample time shorter than 10 min;
- Group 2: Degradation reduced substantially at sample times of 5 min or less;
- Group 3: Degradation reduced substantially at sample times of 5 min or less;
- Group 4: Degradation reduced substantially at sample times of 5 min or less.

The reduction in degradation, relative to that observed for a 10-min sampler, was estimated based on specific sample times in our experiment (using Figure 2 of Calogirou et al.)

Calogirou et al. (1996) conducted experiments with VOC concentrations that were much lower than those occurring for several hours following product use in our chamber. In our experiments, VOC concentrations were often higher than the ozone concentration. Under these circumstances, degradation should have been less than what was observed by Calogirou et al.

In the relevant VOC tables that follow, i.e. those pertaining to experiments in which ozone was used, we have indicated the reported sample concentrations that are expected to be biased low; these are indicated as being either slightly impacted, i.e. roughly on the order of 5-20%, or substantially impacted, i.e. at >30%.

Tables E.14-E.20 present the gas-phase concentrations of perchloroethylene (PCE) and trimethylbenzene (TMB) measured in individual samples. PCE and TMB concentrations were in many cases evaluated using the same samples that were used for determination of other VOCs. Since PCE and TMB concentrations were very low compared to VOC levels following use of GPC-1 and GPD-1, additional sorbent tubes samples of larger air volumes were collected to determine PCE and TMB concentrations during the early hours of these experiments. In analyzing these samples, the MS detector was turned off following quantitation of PCE and TMB to avoid saturation with the large quantities of other VOCs collected in these samples. As noted in §4.4.3, the diffusion vial emission rates and thus the absolute concentrations of both PCE and TMB are sensitive to temperature; the ratio is less sensitive to temperature and therefore is a better indicator of a change in their relative levels owing to the presence of the hydroxyl radical.

Table E.21 presents the concentrations of very volatile carbonyls (formaldehyde, acetaldehyde and acetone) for all samples collected throughout the large chamber experiments. These include duplicate samples for two periods during most experiments. For the cleaning products (GPC-1 and GPD-1) carbonyl samples were collected 0-4 h and 4-12 h following product use. Experiments without ozone served as the controls for experiments with ozone. For

AFR-1 (Exps 3J-3K), the first set of carbonyl samples was collected with the air freshener operating and no ozone in the chamber; sample times are relative to the start of ozone in the supply air. The second set of samples was collected approximately 2-5 h after ozone was introduced to the supply air. Negative values result when the concentrations of a carbonyl measured on blank samplers exceed those measured on air samples collected in experiments.

Figures E.1 through E.11 (top panels) present time- and size-resolved particle number concentrations measured for each experiment using the Lasair optical particle counter (OPC). The size ranges differ somewhat from the nominal bin sizes output by the instrument; the bins shown in these figures are for an oleic acid aerosol and appear to closely approximate the organic aerosol formed from the reaction of ozone and terpenes contained in cleaning products (see §4.3.4). The bottom panel of each figure presents calculated size-resolved particle mass concentrations at specific times of relevance. For the cleaning products (GPC-1 and GPD-1, Figures E.1-E.9), mass concentrations are presented for the period before the start of the cleaning activity, at the time of peak mass concentrations after cleaning, and 3 h after the cleaning event. For the air freshener, particle mass concentrations are shown at the time of the peak before ozone was added, at the time of the peak after ozone was added and at 2 h after ozone was added in each experiment.

Figure E.12 through E.22 show the concentrations recorded by the UV ozone analyzer during each experiment. In experiments in which GPC-1 was used in the absence of ozone, there was an instrument response to some component of GPC-1. The wavelength at which this instrument operates is sensitive to aromatic VOCs. The instrument is designed to account for this and other potential interferences by comparing the unaltered sample air stream to the same air stream after it has passed through an ozone scrubber. To the extent that the instrument is responding to a compound that has been released into the air with GPC-1, one might expect the signal to decay roughly at the air-exchange rate (since this is the base rate at which compounds are being removed from chamber air). But it is evident from Figures E.15-E.16 that the interference signal decreases at a rate that is much faster than air exchange. We therefore cannot offer a complete explanation for the interference signal in these experiments. In the air freshener experiments (3J-3K, Figs E.21-E.22), ozone was introduced to the supply air with the device already operating. This is in contrast to the cleaning product experiments, in which product application occurred in a chamber already containing a steady level of ozone. To illustrate the effect of air freshener VOCs on ozone concentrations, Figures E.22-E.23 include a plot of the ozone concentrations that would be expected in the absence of reactive VOCs, i.e. based solely on the air-exchange rate and the concentration of ozone in the air supply.

Figures E.23-E.25 display the time-dependent temperatures measured in each experiment, grouped by product. Figures E.26-E.28 show analogous data for relative humidity.

**Table E.1.** Airborne concentrations of d-limonene measured in experiment 3B (GPD-1).

Sample ID	Start (min) <sup>a</sup>	End (min) <sup>a</sup>	GC data file	Limonene (ppb)
bk1	-47	-17	50609_05	0.2
1a	4.5	5.5	50609_06	874
1b	4.5	5.5	50611_01	803
2a	19.5	20.5	50609_02	946
3a	40.5	41.5	50609_09	967
4a	59.5	60.5	50609_03	928
4b	60	61	50609_12	900
5a	89.5	90.5	50609_10	917
6a	119	121	50609_04	436
6b	119	121	50613_13	467
7a	178.5	181.5	50609_07	230
8a	358.5	361.5	50609_08	68
9a	544	546.25	50609_11	30
10b	748	754	50609_13	12
11a	1460	1496	50611_04	1.5

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

**Table E.2.** Airborne concentrations of d-limonene measured in experiment 3C (GPD-1)

Sample ID	Start (min) <sup>a</sup>	End (min) <sup>a</sup>	GC data file	Limonene (ppb)
bk1	-94	-74	50612_02	0.0
1a	4	5	50612_12	1007
2a	19	20	50612_03	1408
2b	20	21	50613_08	1350
3a	39	40	50612_13	1002
4a	59	60	50615_10	755
4b	60	61	50612_09	680
5b	90	91	50612_04	377
6a	119	120.5	50612_11	228 <sup>b</sup>
6b	119	120.5	50612_05	205 <sup>b</sup>
7b	146	148	50612_10	116 <sup>b</sup>
8b	188	192	50612_06	55 <sup>b</sup>
9b	238	243	50612_07	28 <sup>b</sup>
10b	356	366	50612_08	5.9 <sup>c</sup>
11a	442	452	50615_14	2.0 <sup>c</sup>
12b	561	579	50612_11	0.4 <sup>c</sup>
13a	720	740	50613_09	0.1 <sup>c</sup>
13b	720	740	50616_06	0.1 <sup>c</sup>

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

<sup>b</sup> Reported concentration estimated to be approximately 5-20% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

<sup>c</sup> Reported concentration estimated to be >30% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

**Table E.3.** Airborne time-integrated concentrations of primary VOCs (ppb) in experiment 3D (GPC-1)

Sample ID	bk1	1a	1c	1d	2c	2d
GC file	50603_10	50603_04	50604_02	50605_07	50604_01	50605_08
Start time (min) <sup>a</sup>	-64	0	0	0	32	32
End time (min) <sup>a</sup>	-23	30	30	30	90	90
$\alpha$ -Pinene	0.02	16.98	14.29	15.03	10.00	8.00
Camphepane	nd	15.06	13.53	14.72	7.55	7.66
$\alpha$ -Terpinene	nd	23.66	12.80	19.79	9.12	8.16
d-Limonene	0.06	209.80	184.82	200.98	96.80	98.49
p-Cymene	0.00	18.75	16.72	19.15	8.58	8.88
$\gamma$ -Terpinene	nd	22.72	20.39	21.09	10.79	10.55
Terpinolene	nd	160.08	94.37	135.63	60.19	61.29
Terpineol ( $\alpha+\gamma$ )	0.02	147.41	125.95	140.11	75.23	74.26
$\alpha$ -Terpineol	nd	128.12	116.00	125.64	67.96	68.72
$\gamma$ -Terpineol	nd	19.50	12.24	15.96	8.21	7.08
Eucalyptol	nd	47.75	43.51	46.45	20.18	20.46
Isoborneol	nd	8.97	9.28	9.01	3.96	3.97
$\alpha$ -Phellandrene	nd	11.41	9.26	10.55	5.38	5.12
Terpene@26.3	nd	9.11	8.43	9.31	4.51	4.46
Terpene@28.2	nd	9.96	6.68	9.09	4.12	3.97
Terpene@29.4	nd	5.47	5.36	5.81	2.43	2.30
1-Terpineol	nd	39.81	37.53	38.71	17.83	17.68
$\beta$ -Terpineol	nd	13.27	12.86	12.97	6.63	6.51
4-Terpineol	nd	8.14	8.81	9.30	4.59	4.30

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

**Table E.3** (continued). Airborne time-integrated concentrations of primary VOCs (ppb) in experiment 3D (GPC-1)

Sample ID	3c	4a	4c	5c
GC file	50604_03	50603_09	50606_07	50605_01
Start time (min)	92	240	240	720
End time (min)	240	720	720	1440

$\alpha$ -Pinene	3.05	0.24	0.23	0.02
Camphepane	2.14	0.25	0.24	nd
$\alpha$ -Terpinene	1.30	0.31	0.31	0.01
d-Limonene	27.51	6.18	5.69	0.47
p-Cymene	2.65	0.70	0.65	0.07
$\gamma$ -Terpinene	2.98	0.68	0.64	0.06
Terpinolene	11.31	3.87	3.68	0.17
Terpineol ( $\alpha+\gamma$ )	34.12	14.99	13.62	2.26
$\alpha$ -Terpineol	32.20	13.66	12.84	2.32
$\gamma$ -Terpineol	2.84	1.19	1.12	0.11
Eucalyptol	4.07	0.61	0.57	0.14
Isoborneol	1.61	0.52	0.46	0.08
$\alpha$ -Phellandrene	1.26	0.26	0.25	0.01
Terpene@26.3	1.27	0.25	0.26	0.02
Terpene@28.2	0.75	0.22	0.21	0.03
Terpene@29.4	0.78	0.18	0.21	0.03
1-Terpineol	7.36	2.25	2.09	0.29
$\beta$ -Terpineol	2.99	1.20	1.13	0.17
4-Terpineol	2.09	0.95	0.61	0.15

**Table E.4.** Airborne, time-resolved concentration measurements of primary VOCs (ppb) in experiment 3E (GPC-1).

Sample ID	x1	x3	x4	x5	x8	x7
GC file	50621_11	50621_12	50622_17	50621_02	50625_02	50621_14
Start (min)	9	19	20	40	59	59
End time (min)	10	20	21	41	61	61

α-Pinene	12.25	9.57	10.08	6.93	4.65	5.07
Camphene	12.64	9.75	10.41	6.93	4.65	5.00
α-Terpinene	10.25	6.63	8.98	12.97	5.95	5.92
d-Limonene	169.15	130.75	139.94	91.72	59.91	64.42
p-Cymene	16.88	12.86	13.27	7.90	5.84	5.91
γ-Terpinene	18.34	13.82	14.94	9.85	6.40	6.88
Terpinolene	73.47	53.72	76.28	81.26	41.34	41.61
Terpineol (α+γ)	136.30	95.51	104.14	68.96	47.33	49.56
α-Terpineol	125.97	88.37	95.52	59.14	41.55	44.88
γ-Terpineol	11.71	8.25	9.50	8.52	5.08	5.04
Eucalyptol	47.36	35.72	38.00	23.61	15.07	16.26
Isoborneol	11.68	7.46	7.30	4.33	2.75	3.05
α-Phellandrene	7.95	5.75	6.66	5.55	3.23	3.44
Terpene@26.3	7.50	5.69	5.97	3.82	2.62	2.84
Terpene@28.2	5.20	3.65	4.92	5.04	2.60	2.65
Terpene@29.4	4.60	3.09	4.11	1.94	1.49	1.70
1-Terpineol	42.63	27.36	28.84	16.59	11.55	12.67
β-Terpineol	14.13	8.60	10.05	5.81	3.84	4.28
4-Terpineol	11.01	7.98	7.93	4.74	3.47	3.47

**Table E.4** (continued). Airborne, time-resolved concentration measurements of primary VOCs (ppb) in experiment 3E (GPC-1).

Sample ID	x9	x12	x11	x13
GC file	50621_04	50625_08	50621_05	50621_10
Start time (min)	118	178	178	365
End time (min)	122	184	184	390
$\alpha$ -Pinene	2.14	1.04	1.07	0.18
Camphepane	2.16	1.04	1.09	0.20
$\alpha$ -Terpinene	3.13	0.66	1.39	0.36
d-Limonene	26.10	13.85	14.37	4.94
p-Cymene	2.49	1.39	1.58	0.61
$\gamma$ -Terpinene	2.82	1.37	1.49	0.53
Terpinolene	22.14	6.62	11.34	3.61
Terpineol ( $\alpha+\gamma$ )	30.95	21.44	22.75	12.75
$\alpha$ -Terpineol	27.15	19.82	20.44	11.51
$\gamma$ -Terpineol	3.43	1.91	2.34	1.17
Eucalyptol	5.34	2.18	2.22	0.57
Isoborneol	1.55	1.10	1.01	0.53
$\alpha$ -Phellandrene	1.50	0.61	0.77	0.24
Terpene@26.3	1.08	0.59	0.60	0.22
Terpene@28.2	1.33	0.39	0.65	0.22
Terpene@29.4	0.55	0.41	0.44	0.19
1-Terpineol	6.61	4.61	4.64	2.13
$\beta$ -Terpineol	2.24	1.65	1.70	0.88
4-Terpineol	1.96	1.38	1.10	0.62

**Table E.4** (continued). Airborne, time-resolved concentration measurements of primary VOCs (ppb) in experiment 3E (GPC-1).

Sample ID	x16	x17	x19
GC file	50621_09	50621_15	50621_16
Start time (min)	482	605	704
End time (min)	502	625	724

$\alpha$ -Pinene	0.08	0.04	0.03
Camphepane	0.08	0.03	0.02
$\alpha$ -Terpinene	0.27	0.15	0.08
d-Limonene	3.03	1.77	1.21
p-Cymene	0.37	0.24	0.18
$\gamma$ -Terpinene	0.37	0.23	0.15
Terpinolene	3.39	2.22	1.46
Terpineol ( $\alpha+\gamma$ )	9.43	6.52	5.19
$\alpha$ -Terpineol	8.49	5.92	4.80
$\gamma$ -Terpineol	0.93	0.65	0.47
Eucalyptol	0.43	0.35	0.29
Isoborneol	0.37	0.26	0.21
$\alpha$ -Phellandrene	0.14	0.07	0.04
Terpene@26.3	0.13	0.07	0.04
Terpene@28.2	0.19	0.12	0.08
Terpene@29.4	0.10	0.07	0.07
1-Terpineol	1.36	0.88	0.64
$\beta$ -Terpineol	0.58	0.41	0.37
4-Terpineol	0.39	0.27	0.21

**Table E.5.** Airborne time-integrated concentrations of primary VOCs (ppb) in experiment 3E (GPC-1)

Sample ID	bk1	1a	1b	2b	3a	4a
GC file	50621_01	50621_07	50622_10	50621_06	50621_08	50621_13
Start time (min) <sup>a</sup>	-76	0	0	30	90	240
End time (min) <sup>a</sup>	-56	30	30	90	240	720
α-Pinene	0.03	9.64	9.65	5.10	1.41	0.14
Camphepane	nd	9.77	9.78	5.07	1.40	0.15
α-Terpinene	nd	21.48	20.55	9.05	1.33	0.12
d-Limonene	0.03	134.31	134.37	65.75	17.98	3.75
p-Cymene	0.00	11.72	12.12	5.91	1.77	0.46
γ-Terpinene	nd	14.69	14.57	7.06	1.92	0.42
Terpinolene	0.01	130.83	126.69	60.85	12.19	2.02
Terpineol (α+γ)	0.11	98.14	95.77	46.09	21.54	8.57
α-Terpineol	0.10	83.97	82.86	40.74	19.41	8.07
γ-Terpineol	0.01	12.70	11.76	5.33	2.26	0.67
Eucalyptol	0.01	32.81	32.93	14.75	2.93	0.45
Isoborneol	0.02	nd	nd	nd	nd	nd
α-Phellandrene	nd	8.43	8.13	3.93	0.92	0.13
Terpene@26.3	nd	5.75	5.80	2.79	0.77	0.16
Terpene@28.2	nd	8.31	8.06	3.74	0.71	0.11
Terpene@29.4	nd	2.44	3.26	1.38	0.45	0.13
1-Terpineol	0.03	26.36	25.59	11.20	4.59	1.47
β-Terpineol	0.03	8.07	8.19	3.82	1.64	0.65
4-Terpineol	0.03	7.84	6.02	2.99	1.27	0.39

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

**Table E.6.** Airborne, time-resolved concentration measurements of primary VOCs (ppb) in experiment 3F (GPC-1).

Sample ID	x2	x3	x5	x7
GC file	50609_15	50607_10	50607_11	50607_04
Start time (min)	9	24	59	120
End time (min)	10	25	60	123

$\alpha$ -Pinene	17.5	12.9	6.3	2.3
Camphene	17.1	12.3	5.9	2.4
$\alpha$ -Terpinene	13.1	1.5	0.0	0.0 <sup>b</sup>
d-Limonene	232.7	176.8	69.1	19.3
p-Cymene	21.0	15.3	7.5	3.1
$\gamma$ -Terpinene	25.7	19.0	6.9	1.9
Terpinolene	235.2	152.1	31.4	3.5 <sup>a</sup>
Terpineol ( $\alpha+\gamma$ )	209.1	168.6	77.6	30.1 <sup>a</sup>
$\alpha$ -Terpineol	179.4	152.8	74.9	31.4
$\gamma$ -Terpineol	26.1	18.5	6.3	1.0 <sup>b</sup>
Eucalyptol	67.0	46.2	20.5	6.5
Isoborneol	-	-	-	-
$\alpha$ -Phellandrene	-	-	-	-
Terpene@26.3	-	-	-	-
Terpene@28.2	-	-	-	-
Terpene@29.4	-	-	-	-
1-Terpineol	-	-	-	-
$\beta$ -Terpineol	-	-	-	-
4-Terpineol	-	-	-	-

**Table E.6** (continued). Airborne, time-resolved concentration measurements of primary VOCs (ppb) in experiment 3F (GPC-1).

Sample ID	x10	x9	x12	x13
GC file	50611_02	50609_14	50607_08	50607_12
Start time (min)	180	180	356	536
End time (min)	183	183	368	551

$\alpha$ -Pinene	0.0	1.0	0.1	0.0
Camphene	1.6	1.2	0.3	0.1
$\alpha$ -Terpinene	0.0 <sup>b</sup>	0.0 <sup>b</sup>	0.0 <sup>b</sup>	0.0 <sup>b</sup>
d-Limonene	8.9 <sup>a</sup>	8.0 <sup>a</sup>	0.8 <sup>b</sup>	0.2 <sup>b</sup>
p-Cymene	1.8	1.9	0.8	0.4
$\gamma$ -Terpinene	0.8 <sup>a</sup>	0.7 <sup>a</sup>	0.1 <sup>b</sup>	0.0 <sup>b</sup>
Terpinolene	0.9 <sup>b</sup>	0.8 <sup>b</sup>	0.0 <sup>b</sup>	0.0 <sup>b</sup>
Terpineol ( $\alpha+\gamma$ )	12.6 <sup>b</sup>	11.8 <sup>b</sup>	0.4 <sup>b</sup>	0.1 <sup>b</sup>
$\alpha$ -Terpineol	13.7 <sup>a</sup>	12.9 <sup>a</sup>	0.5 <sup>b</sup>	0.1 <sup>b</sup>
$\gamma$ -Terpineol	0.2 <sup>b</sup>	0.2 <sup>b</sup>	0.0 <sup>b</sup>	0.0 <sup>b</sup>
Eucalyptol	2.8	2.6	0.8	0.5
Isoborneol	-	-	-	-
$\alpha$ -Phellandrene	-	-	-	-
Terpene@26.3	-	-	-	-
Terpene@28.2	-	-	-	-
Terpene@29.4	-	-	-	-
1-Terpineol	-	-	-	-
$\beta$ -Terpineol	-	-	-	-
4-Terpineol	-	-	-	-

<sup>a</sup> Reported concentration estimated to be approximately 5-20% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

<sup>b</sup> Reported concentration estimated to be >30% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

**Table E.7.** Airborne time-integrated concentrations of primary VOCs (ppb) in experiment 3F (GPC-1).

Sample ID	bk2	1a	1b	2a	2b
GC file	50607_05	50607_02	50611_05	50611_06	50607_03
Start time (min) <sup>a</sup>	-85	0	0	30	30
End time (min) <sup>a</sup>	-55	30	30	90	90

$\alpha$ -Pinene	nd	12.83	13.16	6.84	6.52
Camphene	nd	12.48	12.73	6.52	6.40
$\alpha$ -Terpinene	nd	5.86	4.41	nd	nd
d-Limonene	0.02	169.92	171.88	74.59	72.76
p-Cymene	0.00	14.54	15.36	8.34	7.47
$\gamma$ -Terpinene	nd	19.05	18.89	7.36 <sup>b</sup>	7.73 <sup>b</sup>
Terpinolene	nd	172.91	148.71	33.83 <sup>b</sup>	42.85 <sup>b</sup>
Terpineol ( $\alpha+\gamma$ )	nd	133.87	132.60	68.97	69.58
$\alpha$ -Terpineol	nd	117.95	117.99	65.43	65.48
$\gamma$ -Terpineol	nd	15.95	14.88	5.39 <sup>b</sup>	5.99 <sup>b</sup>
Eucalyptol	0.05	42.88	44.58	20.07	19.50
Isoborneol	nd	nd	nd	nd	nd
$\alpha$ -Phellandrene	0.03	10.09	9.27	2.88 <sup>b</sup>	3.06 <sup>b</sup>
Terpene@26.3	nd	7.59	7.90	3.51	3.45
Terpene@28.2	0.00	9.95	8.69	1.75 <sup>b</sup>	2.13 <sup>b</sup>
Terpene@29.4	0.01	2.48	2.83	1.76	1.09
1-Terpineol	0.01	37.37	38.06	17.75	18.36
$\beta$ -Terpineol	0.02	12.00	12.15	6.18	5.94
4-Terpineol	0.02	9.59	9.77	4.59	4.15

**Table E.7** (continued). Airborne time-integrated concentrations of primary VOCs (ppb) in experiment 3F (GPC-1).

Sample ID	3a	3b	4a	5a
GC file	50607_06	50611_03	50608_08	50608_09
Start time (min)	90	90	240	720
End time (min)	240	240	720	1440

$\alpha$ -Pinene	1.56	1.94	0.09 <sup>b</sup>	0.01 <sup>b</sup>
Camphene	1.72	1.73	0.18	0.01
$\alpha$ -Terpinene	nd	nd	nd	nd
d-Limonene	13.12 <sup>c</sup>	13.21 <sup>c</sup>	0.40 <sup>c</sup>	0.07 <sup>c</sup>
p-Cymene	2.31	2.35	0.68	0.13
$\gamma$ -Terpinene	1.30 <sup>c</sup>	1.30 <sup>c</sup>	0.02 <sup>c</sup>	nd
Terpinolene	1.59 <sup>c</sup>	1.65 <sup>c</sup>	nd	nd
Terpineol ( $\alpha+\gamma$ )	13.17 <sup>c</sup>	15.55 <sup>c</sup>	0.08 <sup>c</sup>	0.01 <sup>c</sup>
$\alpha$ -Terpineol	14.38 <sup>c</sup>	16.79 <sup>c</sup>	0.08 <sup>c</sup>	nd
$\gamma$ -Terpineol	0.19 <sup>c</sup>	0.31 <sup>c</sup>	0.01 <sup>c</sup>	nd
Eucalyptol	3.87	3.90	0.62	0.31
Isoborneol	nd	nd	nd	nd
$\alpha$ -Phellandrene	0.46 <sup>c</sup>	0.45 <sup>c</sup>	0.04 <sup>c</sup>	0.03 <sup>c</sup>
Terpene@26.3	0.71 <sup>c</sup>	0.73 <sup>c</sup>	0.02 <sup>c</sup>	nd
Terpene@28.2	0.08 <sup>c</sup>	0.08 <sup>c</sup>	0.00 <sup>c</sup>	0.00 <sup>c</sup>
Terpene@29.4	0.33 <sup>c</sup>	0.29 <sup>c</sup>	0.01 <sup>c</sup>	0.03 <sup>c</sup>
1-Terpineol	5.73	5.90	1.04	0.16
$\beta$ -Terpineol	2.56	2.71	0.20	0.06
4-Terpineol	0.80 <sup>c</sup>	0.86 <sup>c</sup>	0.23 <sup>c</sup>	0.06 <sup>c</sup>

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

<sup>b</sup> Reported concentration estimated to be approximately 5-20% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

<sup>c</sup> Reported concentration estimated to be >30% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

**Table E.8.** Airborne, time-resolved concentration measurements of primary VOCs (ppb) in experiment 3G (GPC-1).

Sample ID	bk1	x1	x2	x3	x4	x6
GC file	50614_01	50614_05	50620_08	50615_13	50614_12	50614_13
Start time (min) <sup>a</sup>	-63	9	10	14	19	27.5
End time (min) <sup>a</sup>	-43	10	11	15	20	29
$\alpha$ -Pinene	0.01	15.29	14.70	12.97	12.26	9.85
Camphepane	nd	15.18	14.91	12.76	12.06	9.86
$\alpha$ -Terpinene	nd	10.22 <sup>b</sup>	5.45 <sup>b</sup>	2.36	1.32	nd
d-Limonene	0.02	197.19	190.24	179.34	152.11	118.48
p-Cymene	0.00	17.86	19.80	18.30	14.32	11.60
$\gamma$ -Terpinene	nd	21.99	19.26	18.16	16.30	12.54
Terpinolene	nd	200.55 <sup>b</sup>	128.03 <sup>b</sup>	98.34	106.40	75.29
Terpineol ( $\alpha+\gamma$ )	0.01	159.54	149.17	142.46	119.15	94.90
$\alpha$ -Terpineol	nd	136.96	131.32	130.91	107.45	86.23
$\gamma$ -Terpineol	nd	20.04 <sup>b</sup>	16.46 <sup>b</sup>	13.86	12.51	9.36
Eucalyptol	0.02	51.61	49.84	43.31	40.20	32.04
Isoborneol	nd	11.74	11.11	8.92	8.89	6.51
$\alpha$ -Phellandrene	0.06	12.27 <sup>b</sup>	9.92 <sup>b</sup>	8.21	7.64	5.59
Terpene@26.3	0.01	8.87	8.61	7.92	6.88	5.44
Terpene@28.2	nd	12.21 <sup>b</sup>	8.32 <sup>b</sup>	6.04	6.37	4.30
Terpene@29.4	0.02	3.02	4.59	5.20	2.79	2.21
1-Terpineol	0.02	45.48	44.22	39.26	34.28	25.65
$\beta$ -Terpineol	0.04	13.73	14.34	15.06	10.92	8.43
4-Terpineol	0.03	10.27	10.94	10.28	8.51	6.09

**Table E.8** (continued). Airborne, time-resolved concentration measurements of primary VOCs (ppb) in experiment 3G (GPC-1).

Sample ID	x8	x9	x10	x11	x12	x15
GC file	50614_02	50614_14	50614_10	50622_09	50614_03	50614_04
Start time (min)	39	49	59	59	88	118
End time (min)	41	51	61	61	91	122
$\alpha$ -Pinene	7.91	6.50	5.79	5.47	3.32	2.02
Camphepane	7.89	6.43	5.81	5.60	3.38	2.21
$\alpha$ -Terpinene	nd	nd	nd	nd	nd	nd
d-Limonene	92.75	70.81	60.21	57.83	29.73 <sup>b</sup>	16.06 <sup>b</sup>
p-Cymene	9.22	7.77	7.28	7.18	4.22	2.96
$\gamma$ -Terpinene	10.02	7.35	5.93	5.54	3.02 <sup>b</sup>	1.48 <sup>b</sup>
Terpinolene	72.65	31.31	19.82	18.02	8.06 <sup>c</sup>	1.66 <sup>c</sup>
Terpineol ( $\alpha+\gamma$ )	80.84	61.02	54.22	50.76	31.84 <sup>b</sup>	18.93 <sup>b</sup>
$\alpha$ -Terpineol	73.04	57.68	52.54	49.79	32.35 <sup>b</sup>	20.17 <sup>b</sup>
$\gamma$ -Terpineol	8.37	4.98	3.68	3.00	1.60 <sup>c</sup>	0.52 <sup>c</sup>
Eucalyptol	25.01	20.16	17.80	16.96	9.61	5.67
Isoborneol	4.56	4.09	3.43	3.61	2.50	1.84
$\alpha$ -Phellandrene	4.51	2.76	2.08	1.97	0.95 <sup>c</sup>	0.56 <sup>c</sup>
Terpene@26.3	4.31	3.37	2.78	2.68	1.43 <sup>b</sup>	0.86 <sup>b</sup>
Terpene@28.2	3.90	1.71	1.02	0.92	0.40 <sup>c</sup>	0.07 <sup>c</sup>
Terpene@29.4	1.27	1.38	1.09	1.17	0.49 <sup>b</sup>	0.35 <sup>b</sup>
1-Terpineol	19.84	16.31	14.27	13.97	9.17	6.48
$\beta$ -Terpineol	6.78	5.82	5.00	5.05	3.36	2.59
4-Terpineol	4.57	3.96	3.31	3.16	1.93 <sup>b</sup>	1.04 <sup>b</sup>

**Table E.8** (continued). Airborne, time-resolved concentration measurements of primary VOCs (ppb) in experiment 3G (GPC-1).

Sample ID	x17	x18	x20	x21	x22	x23
GC file	50616_05	50614_15	50616_04	50614_07	50616_03	50615_12
Start time (min)	178	265	354	354	713	713
End time (min)	184	274	360	364	733	733
$\alpha$ -Pinene	0.86	0.23 <sup>b</sup>	0.08 <sup>b</sup>	0.07 <sup>b</sup>	0.01 <sup>b</sup>	0.01 <sup>b</sup>
Camphepane	1.10	0.46	0.22	0.22	0.02	0.02
$\alpha$ -Terpinene	nd	nd	nd	nd	nd	nd
d-Limonene	6.31 <sup>b</sup>	1.43 <sup>c</sup>	0.65 <sup>c</sup>	0.45 <sup>c</sup>	0.07 <sup>c</sup>	0.08 <sup>c</sup>
p-Cymene	1.71	1.02	0.71	0.71	0.24	0.24
$\gamma$ -Terpinene	0.56 <sup>b</sup>	0.11 <sup>c</sup>	0.05 <sup>c</sup>	0.03 <sup>c</sup>	nd	nd
Terpinolene	0.21 <sup>c</sup>	0.02 <sup>c</sup>	0.00 <sup>c</sup>	0.00 <sup>c</sup>	nd	nd
Terpineol ( $\alpha+\gamma$ )	6.21 <sup>b</sup>	0.19 <sup>c</sup>	0.30 <sup>c</sup>	0.23 <sup>c</sup>	0.03 <sup>c</sup>	0.03 <sup>c</sup>
$\alpha$ -Terpineol	6.82 <sup>b</sup>	0.20 <sup>c</sup>	0.34 <sup>c</sup>	0.25 <sup>c</sup>	0.02 <sup>c</sup>	0.03 <sup>c</sup>
$\gamma$ -Terpineol	0.08 <sup>c</sup>	0.01 <sup>c</sup>	nd	0.01 <sup>c</sup>	0.01 <sup>c</sup>	0.00 <sup>c</sup>
Eucalyptol	2.36	0.98	0.59	0.62	0.34	0.34
Isoborneol	1.34	0.87	0.66	0.66	0.26	0.27
$\alpha$ -Phellandrene	0.27 <sup>c</sup>	0.12 <sup>c</sup>	0.05 <sup>c</sup>	0.05 <sup>c</sup>	0.00 <sup>c</sup>	nd
Terpene@26.3	0.37 <sup>b</sup>	0.11 <sup>c</sup>	0.04 <sup>c</sup>	0.03 <sup>c</sup>	0.02 <sup>c</sup>	0.01 <sup>c</sup>
Terpene@28.2	0.02 <sup>c</sup>	0.01 <sup>c</sup>	0.03 <sup>c</sup>	0.01 <sup>c</sup>	0.01 <sup>c</sup>	0.01 <sup>c</sup>
Terpene@29.4	0.18 <sup>b</sup>	0.05 <sup>c</sup>	0.02 <sup>c</sup>	0.02 <sup>c</sup>	0.04 <sup>c</sup>	0.02 <sup>c</sup>
1-Terpineol	3.84	1.83	1.02	1.07	0.34	0.37
$\beta$ -Terpineol	1.69	0.72	0.23	0.20	0.10	0.10
4-Terpineol	0.38 <sup>b</sup>	0.10 <sup>c</sup>	nd	0.06 <sup>c</sup>	0.06 <sup>c</sup>	nd

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

<sup>b</sup> Reported concentration estimated to be approximately 5-20% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

<sup>c</sup> Reported concentration estimated to be >30% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

**Table E.9.** Airborne, time-integrated concentrations of primary VOCs (ppb) in experiment 3G (GPC-1).

Sample ID	bk1	1a	1b	2a	3a	4a
GC file	50614_01	50614_08	50622_08	50614_09	50614_11	50614_16
Start time (min) <sup>a</sup>	-63	0	0	30	90	240
End time (min) <sup>a</sup>	-43	30	30	90	240	720
$\alpha$ -Pinene	0.01	12.05	11.71	5.68	1.29	0.07
Camphepane	nd	12.10	11.95	5.68	1.51	0.15
$\alpha$ -Terpinene	nd	3.60	3.76	nd	nd	nd
d-Limonene	0.02	154.85	152.19	61.00	10.40 <sup>c</sup>	0.54 <sup>c</sup>
p-Cymene	0.00	14.64	14.41	7.16	2.14	0.55
$\gamma$ -Terpinene	nd	17.00	16.79	6.00	0.96 <sup>c</sup>	0.03 <sup>c</sup>
Terpinolene	nd	128.02	126.33	25.75 <sup>b</sup>	0.60 <sup>c</sup>	0.00 <sup>c</sup>
Terpineol ( $\alpha+\gamma$ )	0.00	104.61	102.15	46.03	8.36 <sup>c</sup>	0.10 <sup>c</sup>
$\alpha$ -Terpineol	nd	94.51	90.59	44.37	9.16 <sup>c</sup>	0.14 <sup>c</sup>
$\gamma$ -Terpineol	nd	11.72	11.33	3.47 <sup>b</sup>	0.12 <sup>c</sup>	nd
Eucalyptol	0.02	36.74	35.95	15.70	3.15	0.47
Isoborneol	nd	nd	nd	nd	nd	nd
$\alpha$ -Phellandrene	0.06	8.48	8.60	2.31 <sup>b</sup>	0.38 <sup>c</sup>	0.04 <sup>c</sup>
Terpene@26.3	0.01	6.89	6.86	2.80	0.57 <sup>c</sup>	0.03 <sup>c</sup>
Terpene@28.2	nd	7.61	7.79	1.37 <sup>b</sup>	0.07 <sup>c</sup>	0.02 <sup>c</sup>
Terpene@29.4	0.02	3.07	2.71	1.10	0.24 <sup>c</sup>	0.04 <sup>c</sup>
1-Terpineol	0.01	29.64	30.31	12.58	4.06	0.79
$\beta$ -Terpineol	0.03	9.69	8.97	4.58	1.63	0.14
4-Terpineol	0.03	7.99	7.58	3.20	0.58 <sup>c</sup>	0.19 <sup>c</sup>

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

<sup>b</sup> Reported concentration estimated to be approximately 5-20% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

<sup>c</sup> Reported concentration estimated to be >30% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

**Table E.10.** Airborne, time-resolved concentration measurements of primary VOCs (ppb) in experiment 3H (GPC-1).

Sample ID	bk1	x1	x3	x4	x5	x7
GC file	50623_01	50623_04	50623_07	50625_04	50623_02	50623_06
Start time (min) <sup>a</sup>	-53	9	19	20	43	58
End time (min) <sup>a</sup>	-33	10	20	21	45	61
$\alpha$ -Pinene	nd	14.50	11.98	12.04	7.30	5.47
Camphepane	nd	14.66	12.14	12.18	7.35	5.55
$\alpha$ -Terpinene	nd	7.08	1.07	0.68	nd	nd
d-Limonene	0.03	190.78	151.71	151.34	82.53	56.83
p-Cymene	0.01	18.05	14.53	14.94	8.60	6.68
$\gamma$ -Terpinene	nd	20.93	15.90	16.07	8.79	5.94
Terpinolene	nd	168.55	96.09	75.20	55.43	26.61
Terpineol ( $\alpha+\gamma$ )	nd	176.44	136.90	132.31	79.79	57.62
$\alpha$ -Terpineol	nd	152.02	123.37	121.14	72.08	54.87
$\gamma$ -Terpineol	nd	20.90	13.92	12.23	7.55	4.65
Eucalyptol	0.11	52.12	41.70	41.72	24.41	17.68
Isoborneol	nd	13.58	9.15	9.81	4.55	3.58
$\alpha$ -Phellandrene	0.04	11.08	7.31	6.75	3.69	2.15
Terpene@26.3	nd	8.52	6.42	6.68	3.75	2.68
Terpene@28.2	nd	10.42	5.73	4.64	2.88	1.31
Terpene@29.4	0.01	3.73	2.63	2.89	1.13	0.91
1-Terpineol	0.04	48.61	35.10	35.45	19.03	14.43
$\beta$ -Terpineol	0.04	13.65	11.03	11.00	7.58	5.01
4-Terpineol	0.03	12.63	9.55	9.73	4.95	3.58

**Table E.10** (continued). Airborne, time-resolved concentration measurements of primary VOCs (ppb) in experiment 3H (GPC-1).

Sample ID	x9	x11	x12	x13	x15	x17
GC file	50623_08	50623_09	50625_03	50623_11	50623_12	50623_13
Start time (min)	116	175	175	230	350	470
End time (min)	124	185	185	250	370	490
$\alpha$ -Pinene	1.95	0.83	0.87	0.38 <sup>b</sup>	0.07 <sup>b</sup>	0.03 <sup>b</sup>
Camphepane	2.17	1.09	1.13	0.61	0.20	0.09
$\alpha$ -Terpinene	nd	nd	nd	nd	nd	nd
d-Limonene	15.43	6.04 <sup>b</sup>	6.37 <sup>b</sup>	2.00 <sup>c</sup>	0.39 <sup>c</sup>	0.16 <sup>c</sup>
p-Cymene	2.89	1.65	1.69	1.16	0.64	0.49
$\gamma$ -Terpinene	1.48	0.55 <sup>b</sup>	0.58 <sup>b</sup>	0.16 <sup>c</sup>	0.02 <sup>c</sup>	0.01 <sup>c</sup>
Terpinolene	1.45 <sup>c</sup>	0.23 <sup>c</sup>	0.23 <sup>c</sup>	0.02 <sup>c</sup>	nd	nd
Terpineol ( $\alpha+\gamma$ )	19.85	6.67 <sup>b</sup>	6.95 <sup>b</sup>	1.11 <sup>c</sup>	0.16 <sup>c</sup>	0.08 <sup>c</sup>
$\alpha$ -Terpineol	20.70	7.17 <sup>b</sup>	7.49 <sup>b</sup>	1.19 <sup>c</sup>	0.18 <sup>c</sup>	0.08 <sup>c</sup>
$\gamma$ -Terpineol	0.49 <sup>c</sup>	0.08 <sup>c</sup>	0.07 <sup>c</sup>	0.02 <sup>c</sup>	0.00 <sup>c</sup>	0.01 <sup>c</sup>
Eucalyptol	5.74	2.53	2.58	1.37	0.65	0.56
Isoborneol	2.01	1.39	1.43	1.04	0.62	0.52
$\alpha$ -Phellandrene	1.24 <sup>c</sup>	0.26 <sup>c</sup>	0.26 <sup>c</sup>	0.14 <sup>c</sup>	0.05 <sup>c</sup>	0.02 <sup>c</sup>
Terpene@26.3	0.85	0.39 <sup>b</sup>	0.39 <sup>b</sup>	0.17 <sup>c</sup>	0.03 <sup>c</sup>	0.01 <sup>c</sup>
Terpene@28.2	0.08 <sup>c</sup>	0.02	nd	0.01 <sup>c</sup>	0.00 <sup>c</sup>	0.01 <sup>c</sup>
Terpene@29.4	0.33	0.16 <sup>b</sup>	0.18 <sup>b</sup>	0.05 <sup>c</sup>	0.02 <sup>c</sup>	0.01 <sup>c</sup>
1-Terpineol	7.29	4.14	4.32	2.34	1.04	0.80
$\beta$ -Terpineol	2.86	1.79	1.79	0.99	0.19	0.07
4-Terpineol	1.04	0.44 <sup>b</sup>	nq <sup>d</sup>	0.07 <sup>c</sup>	0.04 <sup>c</sup>	nd

**Table E.10** (continued) Airborne, time-resolved concentration measurements of primary VOCs (ppb) in experiment 3H (GPC-1).

Sample ID	x19	x21
GC file	50623_18	50623_14
Start time (min)	582	724
End time (min)	602	744

$\alpha$ -Pinene	0.02	0.01
Camphepane	0.05	0.03
$\alpha$ -Terpinene	nd	nd
d-Limonene	0.16 <sup>c</sup>	0.09 <sup>c</sup>
p-Cymene	0.35	0.24
$\gamma$ -Terpinene	0.01 <sup>c</sup>	nd
Terpinolene	0.01 <sup>c</sup>	nd
Terpineol ( $\alpha+\gamma$ )	0.14 <sup>c</sup>	0.04 <sup>c</sup>
$\alpha$ -Terpineol	0.13 <sup>c</sup>	0.03 <sup>c</sup>
$\gamma$ -Terpineol	0.01 <sup>c</sup>	0.01 <sup>c</sup>
Eucalyptol	0.49	0.45
Isoborneol	0.37	0.30
$\alpha$ -Phellandrene	0.01 <sup>c</sup>	nd
Terpene@26.3	0.01 <sup>c</sup>	nd
Terpene@28.2	nd	nd
Terpene@29.4	nd	nd
1-Terpineol	0.59	0.45
$\beta$ -Terpineol	nd	0.02
4-Terpineol	nd	nd

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

<sup>b</sup> Reported concentration estimated to be approximately 5-20% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

<sup>c</sup> Reported concentration estimated to be >30% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

<sup>d</sup> Not quantifiable, owing to poor peak resolution from the gas chromatograph.

**Table E.11.** Airborne, time-integrated concentrations of primary VOCs (ppb) in experiment 3H (GPC-1).

Sample ID	bk1	1a	2a	3a	4a
GC file	50623_01	50623_05	50623_03	50623_10	50623_15
Start time (min) <sup>a</sup>	-53	0	30	90	240
End time (min) <sup>a</sup>	-33	30	90	240	723

$\alpha$ -Pinene	nd	11.68	5.64	1.25	0.07 <sup>b</sup>
Camphepane	nd	11.92	5.81	1.49	0.15
$\alpha$ -Terpinene	nd	2.76	nd	nd	nd
d-Limonene	0.03	152.96	62.12	10.18 <sup>c</sup>	0.28 <sup>c</sup>
p-Cymene	0.01	14.69	6.96	2.12	0.56
$\gamma$ -Terpinene	nd	16.50	6.44	0.94 <sup>c</sup>	0.01 <sup>c</sup>
Terpinolene	nd	113.49	33.56 <sup>b</sup>	0.40 <sup>c</sup>	nd
Terpineol ( $\alpha+\gamma$ )	nd	117.13	52.13	8.06 <sup>c</sup>	0.03 <sup>c</sup>
$\alpha$ -Terpineol	nd	103.64	49.94	8.81 <sup>c</sup>	0.02 <sup>c</sup>
$\gamma$ -Terpineol	nd	12.95	3.95 <sup>b</sup>	0.07 <sup>c</sup>	0.01 <sup>c</sup>
Eucalyptol	0.10	37.55	16.46	3.32	0.57
Isoborneol	nd	8.63	3.52	1.39	0.48
$\alpha$ -Phellandrene	0.04	7.92	2.46 <sup>b</sup>	0.36 <sup>c</sup>	0.03 <sup>c</sup>
Terpene@26.3	nd	6.64	2.80	0.58 <sup>c</sup>	0.02 <sup>c</sup>
Terpene@28.2	nd	6.78	1.66 <sup>b</sup>	0.04 <sup>c</sup>	0.00 <sup>c</sup>
Terpene@29.4	0.01	2.74	0.87	0.17 <sup>c</sup>	0.01 <sup>c</sup>
1-Terpineol	0.04	31.98	13.46	4.41	0.83
$\beta$ -Terpineol	0.03	10.02	4.62	1.86	0.11
4-Terpineol	0.03	8.59	2.94	0.56 <sup>c</sup>	0.06 <sup>c</sup>

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

<sup>b</sup> Reported concentration estimated to be approximately 5-20% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

<sup>c</sup> Reported concentration estimated to be >30% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

**Table E.12.** Airborne concentration measurements of primary VOCs (ppb) in experiment 3J (AFR-1)

Sample ID	1a	1b	2a	2b	3a	4b
GC file	50626_02	50626_03	50626_08	50626_11	50626_04	50626_05
Start time (min) <sup>a</sup>	-180	-180	-24	-24	15	57
End time (min) <sup>a</sup>	-168	-168	-12	-12	27	71

d-Limonene	2.68	3.13	2.41	2.49	1.81 <sup>d</sup>	0.92 <sup>e</sup>
Dihydromyrcenol	11.13	12.94	10.44	10.30	10.09	9.25 <sup>d</sup>
Linalool	7.28	8.57	6.80	6.71	3.58 <sup>e</sup>	0.80 <sup>e</sup>
Linalyl acetate <sup>b</sup>	3.50	4.07	3.36	3.63	1.66 <sup>e</sup>	0.41 <sup>e</sup>
β-Citronellol	1.75	2.04	1.65	1.68	0.59 <sup>d</sup>	0.12
α-Citral	0.52	0.46	0.40	0.43	0.28 <sup>e</sup>	nd <sup>c</sup>
Benzyl acetate	16.43	19.07	15.76	15.60	15.59	15.61
Bornyl acetate	4.49	5.30	4.33	4.35	4.22	4.29

**Table E.12 (continued).** Airborne concentration measurements of primary VOCs (ppb) in experiment 3J (AFR-1).

Sample ID	5a	5b	6a	7b	8a
GC file	50626_06	50628_03	50626_07	50626_09	50626_12
Start time (min)	112	112	173	235	298
End time (min)	128	128	189	251	314

d-Limonene	0.55 <sup>e</sup>	0.67 <sup>e</sup>	0.41 <sup>e</sup>	0.37 <sup>e</sup>	0.39 <sup>e</sup>
Dihydromyrcenol	8.30 <sup>d</sup>	8.84 <sup>d</sup>	7.35 <sup>d</sup>	6.55 <sup>d</sup>	6.18 <sup>d</sup>
Linalool	0.43 <sup>e</sup>	0.51 <sup>e</sup>	0.31 <sup>e</sup>	0.32 <sup>e</sup>	0.28 <sup>e</sup>
Linalyl acetate <sup>b</sup>	0.27	nd <sup>c</sup>	nd	nd	nd
β-Citronellol	0.08 <sup>e</sup>	0.10 <sup>e</sup>	0.07 <sup>e</sup>	0.05 <sup>e</sup>	0.05 <sup>e</sup>
α-Citral	nd	nd	nd	nd	nd
Benzyl acetate	15.57	16.52	15.68	15.51	15.21
Bornyl acetate	4.34	4.62	4.36	4.34	4.23

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

<sup>b</sup> Quantified by total ion current based on response of linalool.

<sup>c</sup> nd = not detected

<sup>d</sup> Reported concentration estimated to be approximately 5-20% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

<sup>e</sup> Reported concentration estimated to be >30% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

**Table E.13.** Airborne concentration measurements of primary VOCs (ppb) in experiment 3K (AFR-1).

Sample ID	bk1	1b	2a	3b	4a
GC file	50627_03	50627_12	50627_06	50627_07	50628_02
Start time (min) <sup>a</sup>	-255	-140	-27	10	50
End time (min) <sup>a</sup>	-243	-120	-7	30	70

d-Limonene	1.55	1.57	1.57	0.91 <sup>d</sup>	0.70 <sup>e</sup>
Dihydromyrcenol	6.92	6.71	6.94	6.38	6.35 <sup>d</sup>
Linalool	4.30	4.27	4.52	1.39 <sup>e</sup>	0.59 <sup>e</sup>
Linalyl acetate <sup>b</sup>	2.28	2.23	2.45	0.57 <sup>e</sup>	0.37 <sup>e</sup>
β-Citronellol	1.05	1.12	1.22	0.20 <sup>d</sup>	0.08 <sup>e</sup>
α-Citral	0.30	0.30	0.35	nd <sup>c</sup>	nd
Benzyl acetate	11.55	11.48	11.84	11.37	11.68
Bornyl acetate	2.98	2.98	3.10	2.97	3.07

**Table E.13** (continued). Airborne concentration measurements of primary VOCs (ppb) in experiment 3K (GPC-1).

Sample ID	4b	5a	6a	7a	8a
GC file	50627_13	50627_08	50627_09	50627_10	50627_11
Start time (min)	50	105	165	225	285
End time (min)	70	135	195	255	315

d-Limonene	0.41 <sup>e</sup>	0.22 <sup>e</sup>	0.33 <sup>e</sup>	0.17 <sup>e</sup>	0.19 <sup>e</sup>
Dihydromyrcenol	5.88 <sup>d</sup>	4.94 <sup>d</sup>	4.79 <sup>d</sup>	3.93 <sup>d</sup>	3.78 <sup>d</sup>
Linalool	0.26 <sup>e</sup>	0.14 <sup>e</sup>	0.23 <sup>e</sup>	0.10 <sup>e</sup>	0.11 <sup>e</sup>
Linalyl acetate <sup>b</sup>	0.19 <sup>e</sup>	nd <sup>c</sup>	nd	nd	nd
β-Citronellol	0.04 <sup>e</sup>	0.03 <sup>e</sup>	0.02 <sup>e</sup>	0.01 <sup>e</sup>	0.01 <sup>e</sup>
α-Citral	nd	nd	nd	nd	nd
Benzyl acetate	11.39	11.48	11.81	10.90	11.04
Bornyl acetate	2.97	3.10	3.16	2.94	2.95

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

<sup>b</sup> Quantified by total ion current based on response of linalool.

<sup>c</sup> nd = not detected

<sup>d</sup> Reported concentration estimated to be approximately 5-20% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

<sup>e</sup> Reported concentration estimated to be >30% lower than actual because of sampling losses on Tenax in presence of ozone. See text at start of Appendix E.

**Table E.14.** Sample information and results for PCE and TMB, Expt 3C.

Sample ID	Start time (min) <sup>a</sup>	End time (min) <sup>a</sup>	GC file	PCE (ppb)	TMB (ppb)	TMB/PCE
bk1	-94	-74	50612_01	0.427	0.721	1.688
bk2	-94	-74	50613_11	0.403	0.704	1.748
bk3	-72	-52	50616_10	0.415	0.717	1.727
bk4	-72	-52	50620_07	0.428	0.761	1.777
pce1	22	38	50612_15	0.408	0.705	1.727
pce2	22	38	50613_10	0.404	0.685	1.694
pce3	62	82	50613_12	0.429	0.724	1.689
pce4	62	82	50616_09	0.437	0.753	1.725
pce5	95	105	50612_14	0.452	0.757	1.676
pce6	95	105	50616_07	0.450	0.767	1.705
pce7	150	170	50612_15	0.431	0.711	1.651
pce8	150	170	50616_08	0.457	0.741	1.621
10a	356	364	50616_11	0.457	0.709	1.552
10b	356	366	50612_08	0.441	0.696	1.578
11a	442	452	50615_14	0.441	0.726	1.647
11b	442	452	50616_12	0.438	0.698	1.595
12b	561	579	50612_11	0.445	0.701	1.577
13a	720	740	50613_09	0.424	0.688	1.621
13b	720	740	50616_06	0.426	0.702	1.650

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

**Table E.15.** Sample information and results for PCE and TMB, Expt 3E.

Sample ID	Start time (min) <sup>a</sup>	End time (min) <sup>a</sup>	GC file	PCE (ppb)	TMB (ppb)	TMB/PCE
bk1	-76	-56	50621_01	0.400	0.704	1.760
bk2	-76	-56	50625_05	0.411	0.718	1.746
bk3	-55	-32	50622_16	0.397	0.679	1.708
pce1	22	38	50622_11	0.402	0.698	1.736
pce4	65	85	50622_12	0.405	0.697	1.723
pce6	140	160	50622_13	0.429	0.729	1.699
pce7	230	250	50622_14	0.446	0.770	1.726
pce9	344	364	50622_15	0.488	0.852	1.746
x11	178	184	50621_05	0.434	0.768	1.769
x12	178	184	50625_08	0.436	0.752	1.726
x13	365	390	50621_10	0.475	0.856	1.801
x14	365	390	50625_07	0.492	0.878	1.787
x16	482	502	50621_09	0.482	0.871	1.810
x17	605	625	50621_15	0.462	0.809	1.751
x19	704	724	50621_16	0.439	0.774	1.764
3a	90	240	50621_08	0.416	0.729	1.752
4a	240	720	50621_13	0.461	0.820	1.778

<sup>a</sup> Times are referenced to the start of the simulated-use activity.**Table E.16.** Sample information and results for PCE and TMB, Expt 3G.

Sample ID	Start time (min) <sup>a</sup>	End time (min) <sup>a</sup>	GC file	PCE (ppb)	TMB (ppb)	TMB/PCE
bk1	-63	-43	50614_01	0.412	0.716	1.736
bk2	-63	-43	50616_02	0.420	0.708	1.686
x17	178	184	50616_05	0.453	0.704	1.554
x18	265	274	50614_15	0.452	0.694	1.535
x20	354	360	50616_04	0.447	0.708	1.585
x21	354	364	50614_07	0.445	0.708	1.592
x22	713	733	50616_03	0.444	0.738	1.664
x23	713	733	50615_12	0.452	0.757	1.674
3a	90	240	50614_11	0.434	0.691	1.591
4a	240	720	50614_16	0.459	0.733	1.596

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

**Table E.17.** Sample information and results for PCE and TMB, Expt 3H.

Sample ID	Start time (min) <sup>a</sup>	End time (min) <sup>a</sup>	GC file	PCE (ppb)	TMB (ppb)	TMB/PCE
bk1	-53	-33	50623_01	0.413	0.696	1.684
bk3	-32	-12	50624_05	0.411	0.690	1.676
pce1	22	38	50623_16	0.405	0.659	1.627
pce3	65	85	50623_17	0.420	0.660	1.571
x9	116	124	50623_08	0.424	0.663	1.565
x11	175	185	50623_09	0.419	0.655	1.565
x12	175	185	50625_03	0.427	0.674	1.579
x13	230	250	50623_11	0.425	0.657	1.546
x15	350	370	50623_12	0.387	0.605	1.562
x17	470	490	50623_13	0.437	0.696	1.593
x19	582	602	50623_18	0.425	0.684	1.608
x21	724	744	50623_14	0.439	0.712	1.621
3a	90	240	50623_10	0.417	0.659	1.579
4a	240	723	50623_15	0.432	0.689	1.597

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

**Table E.18.** Sample information and results for PCE and TMB, Expt 3I.

Sample ID	Start time (min) <sup>a</sup>	End time (min) <sup>a</sup>	GC file	PCE (ppb)	TMB (ppb)	TMB/PCE
bk2	-30	0	50602_12	0.470	0.811	1.725
1a	10	30	50602_09	0.433	0.746	1.723
2a	32	90	50602_11	0.420	0.738	1.757
3a	92	240	50602_10	0.447	0.765	1.713
4a	240	720	50602_13	0.464	0.798	1.722

<sup>a</sup> Times are referenced to the start of the simulated-use activity.

**Table E.19.** Sample information and results for PCE and TMB, Expt 3J.

Sample ID	Start time (min) <sup>a</sup>	End time (min) <sup>a</sup>	GC file	PCE (ppb)	TMB (ppb)	TMB/PCE
1a	-180	-168	50626_02	0.415	0.719	1.730
1b	-180	-168	50626_03	0.486	0.841	1.730
2a	-24	-12	50626_09	0.412	0.709	1.720
2b	-24	-12	50626_11	0.410	0.712	1.737
3a	15	27	50626_04	0.408	0.698	1.710
4b	57	71	50626_05	0.410	0.683	1.667
5a	112	128	50626_06	0.418	0.696	1.664
5b	112	128	50628_03	0.435	0.736	1.691
6a	173	189	50626_07	0.432	0.713	1.650
7b	235	251	50626_08	0.429	0.704	1.642
8a	298	314	50626_12	0.415	0.684	1.649
post	700	710	50626_13	0.421	0.731	1.738

<sup>a</sup> Times are referenced to the beginning of ozone supply to the chamber.**Table E.20.** Sample information and results for PCE and TMB, Expt 3K.

Sample ID	Start (min) <sup>a</sup>	End (min) <sup>a</sup>	GC file	PCE (ppb)	TMB (ppb)	TMB/PCE
bk1	-255	-243	50627_03	0.402	0.704	1.752
1b	-140	-120	50627_12	0.419	0.723	1.727
2a	-27	-7	50627_06	0.438	0.769	1.755
3b	10	30	50627_07	0.425	0.722	1.700
4a	50	70	50628_02	0.432	0.725	1.678
4b	50	70	50627_13	0.422	0.714	1.692
5a	105	135	50627_08	0.439	0.737	1.680
6a	165	195	50627_09	0.455	0.749	1.647
7a	225	255	50627_10	0.425	0.703	1.655
8a	285	315	50627_11	0.435	0.705	1.621

<sup>a</sup> Times are referenced to the beginning of ozone supply to the chamber.

**Table E.21.** Airborne concentrations of very volatile carbonyls (ppb), measured in experiments 3A-3K.<sup>a</sup>

Expt	ID	Start (min) <sup>b</sup>	End (min) <sup>b</sup>	HPLC Sequence	HPLC file	HCHO (ppb)	Acetaldehyde (ppb)	Acetone (ppb)
3A	1a	0	240	50615_a	050-2101	5.7	1.0	1.4
3A	1b	0	240	50615_a	051-2201	5.2	0.7	1.0
3B	1a	0	255	50615_a	058-2901	10.0	1.2	2.7
3B	1b	0	255	50622_b	030-0201	9.5	1.1	2.6
3B	2a	263	745	50622_b	031-0301	9.4	1.1	1.4
3B	2b	264	745	50622_b	032-0401	9.4	1.1	1.4
3C	1a	0	253	50622_b	033-0501	23.1	2.0	3.7
3C	1b	0	254	50622_b	034-0601	24.4	2.5	4.1
3C	2a	261	741	50622_b	035-0701	18.0	1.9	2.6
3C	2b	262	742	50622_b	036-0801	17.8	1.9	2.5
3D	1a	0	242	50615_a	046-1701	8.5	1.8	2.7
3D	1b	0	242	50615_a	047-1801	8.1	1.1	2.7
3D	2a	245	720	50615_a	048-1901	7.5	1.8	1.5
3D	2b	245	720	50615_a	049-2001	7.6	1.7	1.6
3E	1a	0	237	50622_c	011-0201	5.1	1.3	2.2
3E	1a	0	238	50622_c	012-0301	6.9	0.7	2.4
3E	2a	242	714	50622_c	015-0601	7.5	0.9	1.6
3E	2b	243	715	50622_c	016-0701	7.3	0.9	1.7
3F	1a	0	240	50615_a	057-2801	15.2	1.9	32.3
3F	1b	0	240	50615_a	056-2701	14.4	1.7	30.3
3F	2a	242	720	50615_a	055-2601	10.7	1.9	9.8
3F	2b	242	720	50615_a	054-2501	10.9	1.9	9.5
3G	1a	0	235	50622_b	037-0901	17.5	2.1	31.5
3G	1b	0	236	50622_b	038-1001	17.5	2.3	32.3
3G	2a	239	720	50622_b	039-1101	12.2	2.6	7.6
3G	2b	240	720	50622_c	010-0101	11.1	1.9	7.3

<sup>a</sup> Concentrations in air calculated by first subtracting mean analyte yields of blank cartridges from measured sample yields, then dividing by the volume of sampled air. Negative concentrations result when the analytical blanks contained more mass than the sample cartridges.

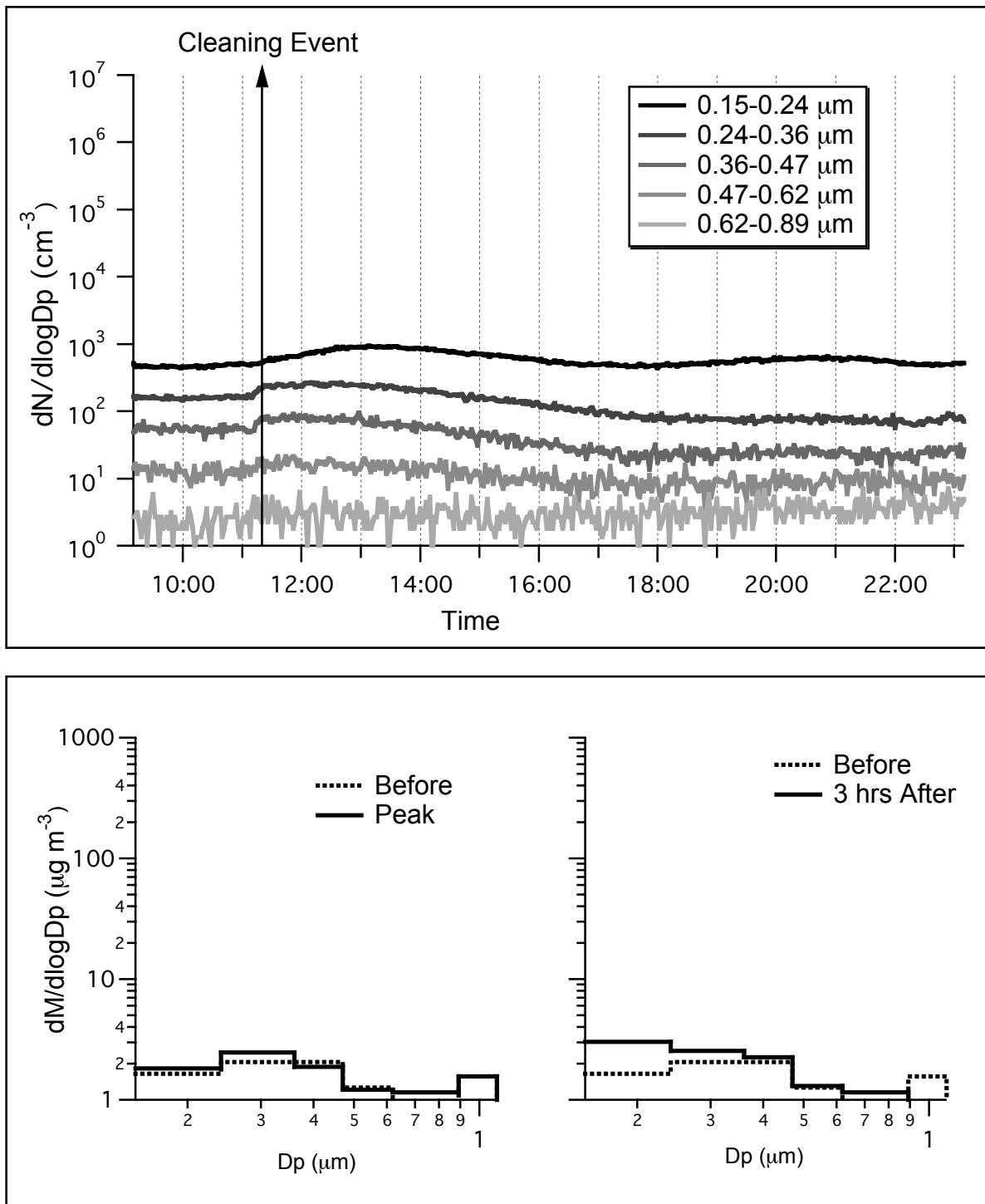
<sup>b</sup> Times referenced to the beginning of the simulated use activity (experiments 3A-3I) or to the beginning of ozone supply to the chamber (experiments 3J-3K).

**Table E.21** (continued). Airborne concentrations of very volatile carbonyls (ppb), measured in experiments 3A-3K.<sup>a</sup>

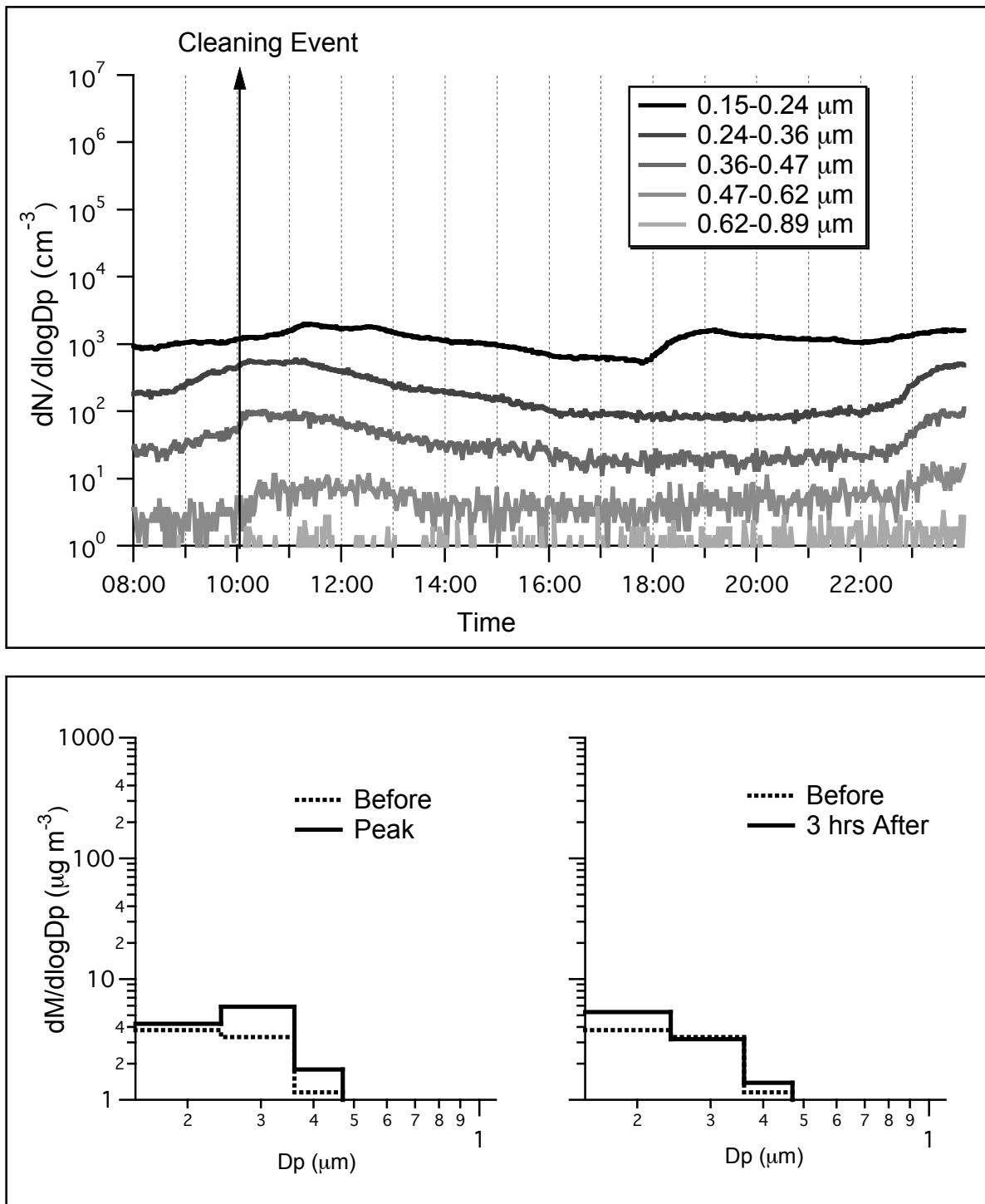
Expt	ID	Start (min) <sup>b</sup>	End (min) <sup>b</sup>	HPLC Sequence	HPLC file	HCHO (ppb)	Acetaldehyde (ppb)	Acetone (ppb)
3H	1a	0	238	50711_b	012-0101	15.9	1.5	32.0
3H	1b	0	239	50711_b	013-0201	15.3	1.0	30.1
3H	2a	243	705	50711_b	014-0301	10.0	1.2	7.0
3H	2b	244	706	50711_b	015-0401	10.7	1.7	7.9
3I	1a	0	240	50615_a	043-1401	9.6	3.0	2.1
3I	1b	0	241	50615_a	042-1301	10.7	3.1	2.0
3I	2a	245	723	50615_a	041-1201	9.4	2.6	1.5
3I	2b	247	724	50615_a	040-1101	9.5	3.1	1.4
3J	1a	-189	-9	50711_b	016-0501	5.2	-0.2	-0.1
3J	1b	-188	-8	50711_b	017-0601	5.6	0.0	0.1
3J	2a	120	300	50711_b	018-0701	11.7	1.0	17.7
3J	2b	121	301	50711_b	019-0801	12.6	1.0	17.7
3K	1a	-182	-2	50711_b	021-1001	6.0	-0.8	-1.3
3K	1a	-182	-2	50712_a	021-0501	5.5	-0.9	-1.7
3K	1b	-181	-1	50712_a	022-0301	5.4	-0.7	-1.0
3K	2a	118	298	50712_a	023-0401	10.0	0.6	10.6
3K	2b	119	299	50712_a	024-0601	10.5	0.1	10.8

<sup>a</sup> Concentrations in air calculated by first subtracting mean analyte yields of blank cartridges from measured sample yields, then dividing by the volume of sampled air. Negative concentrations result when the analytical blanks contained more mass than the sample cartridges.

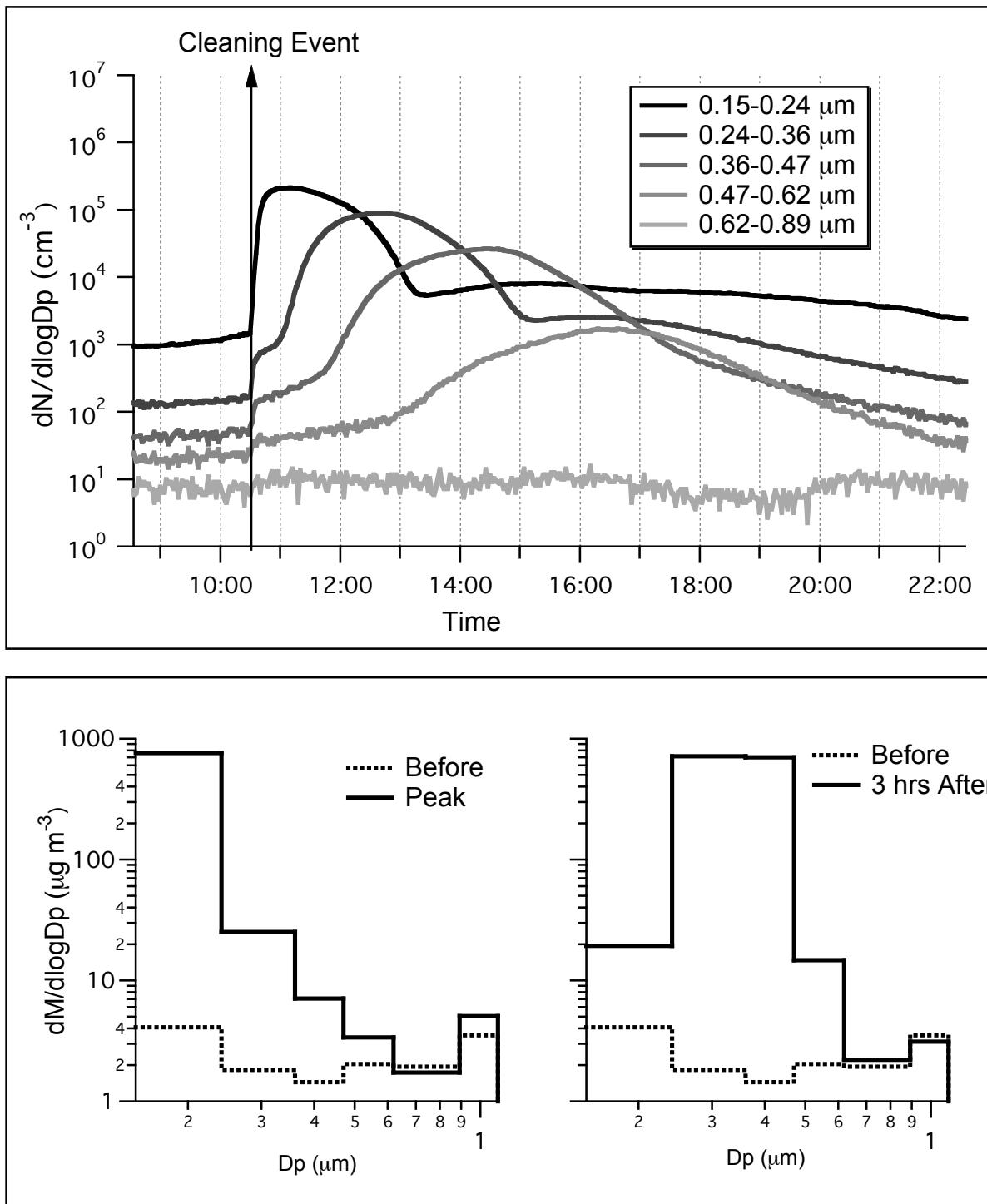
<sup>b</sup> Times referenced to the beginning of the simulated use activity (experiments 3A-3I) or to the beginning of ozone supply to the chamber (experiments 3J-3K).



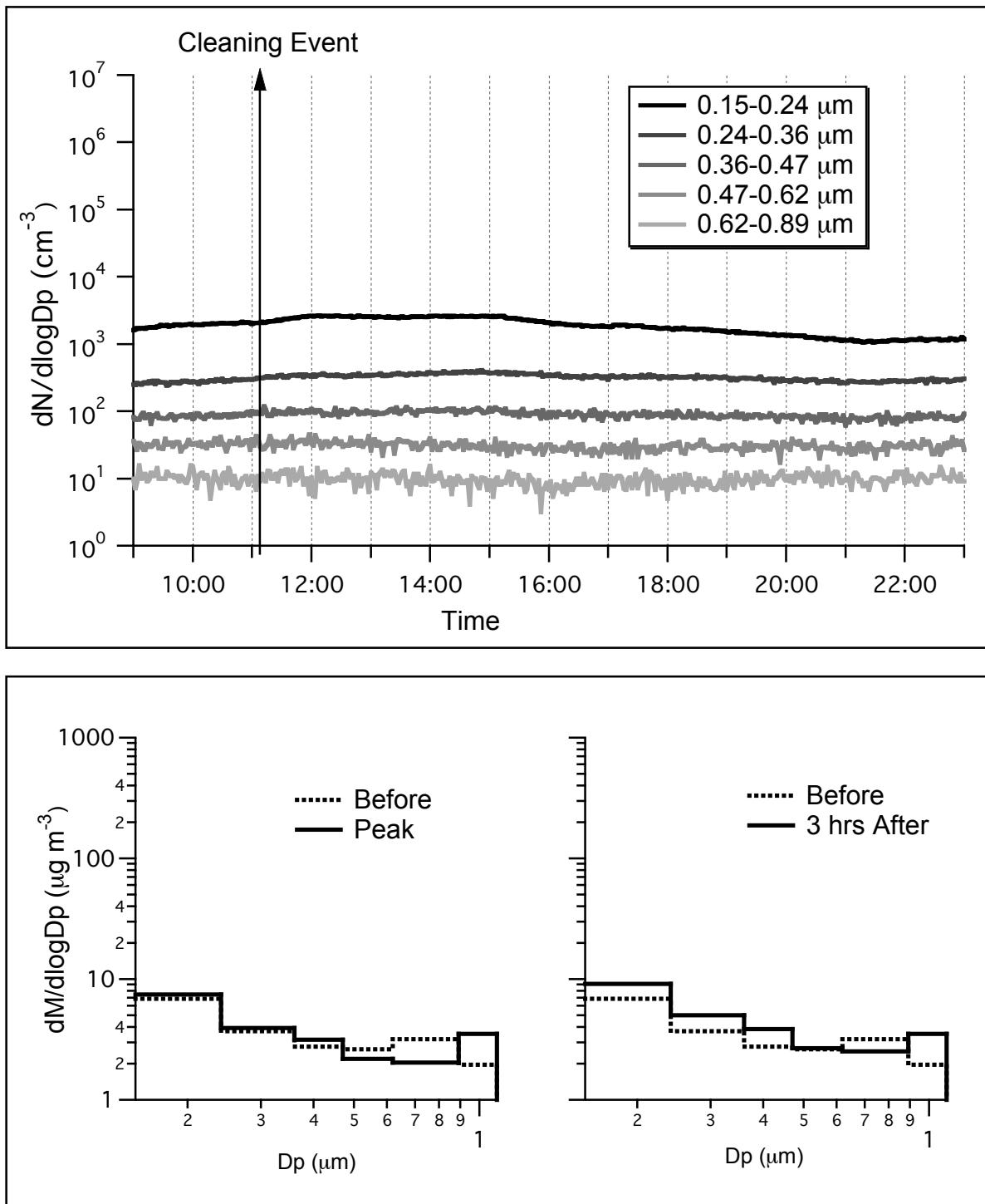
**Figure E.1.** OPC measurements of aerosol particles during Expt 3A (GPD-1, no ozone).



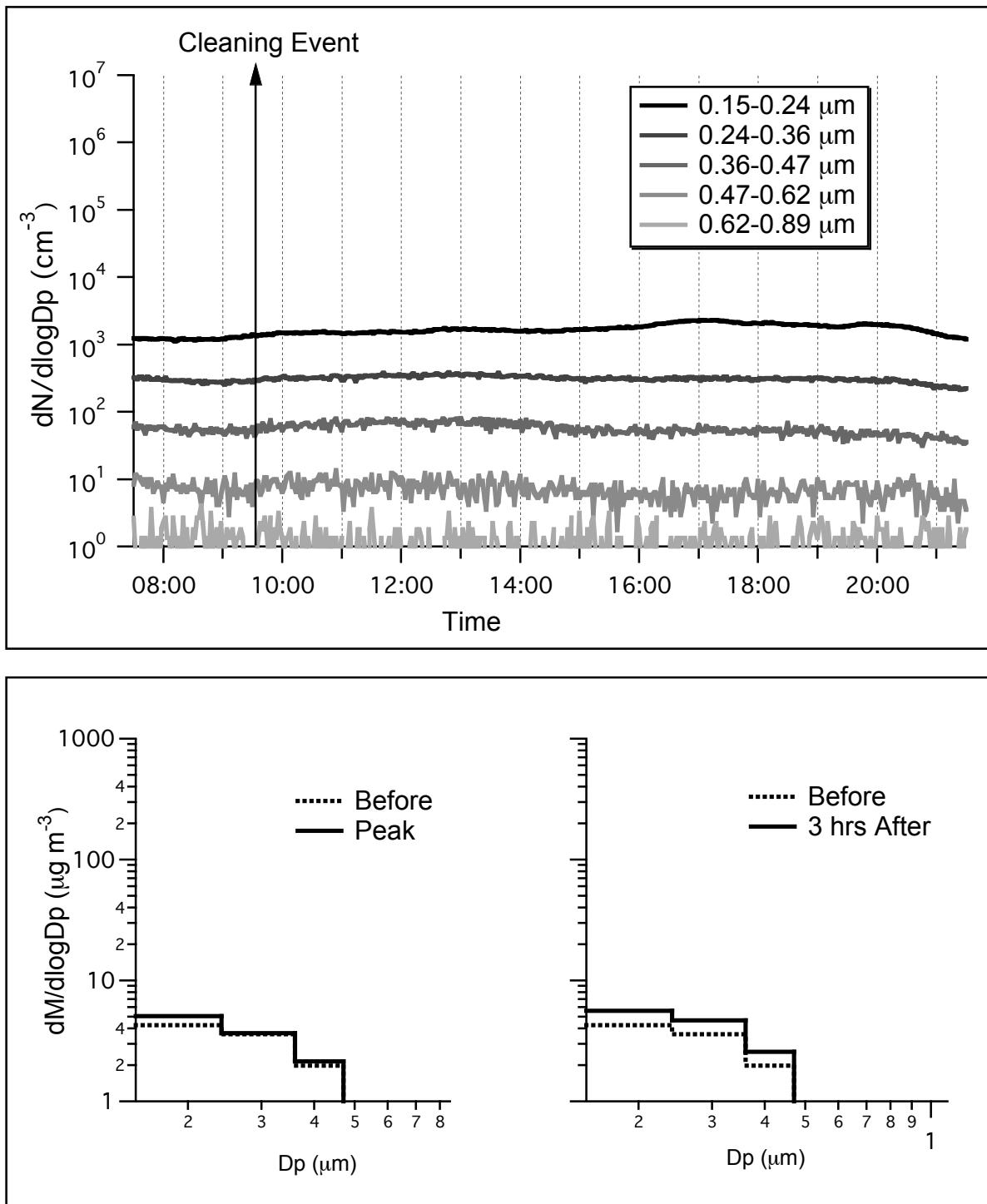
**Figure E.2.** OPC measurements of aerosol particles during Expt 3B (GPD-1, no ozone).



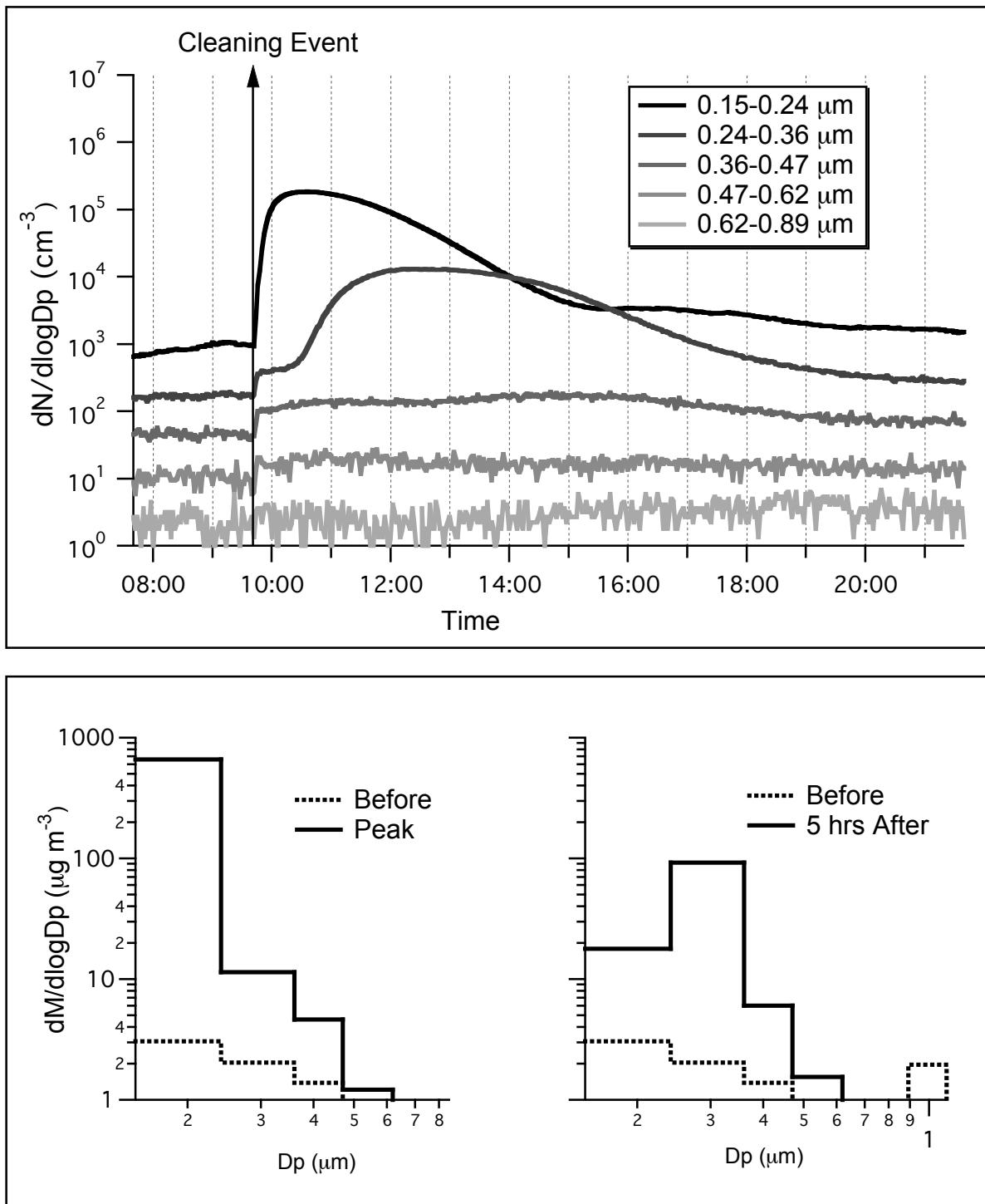
**Figure E.3.** OPC measurements of aerosol particles during Expt 3C (GPD-1, with ozone).



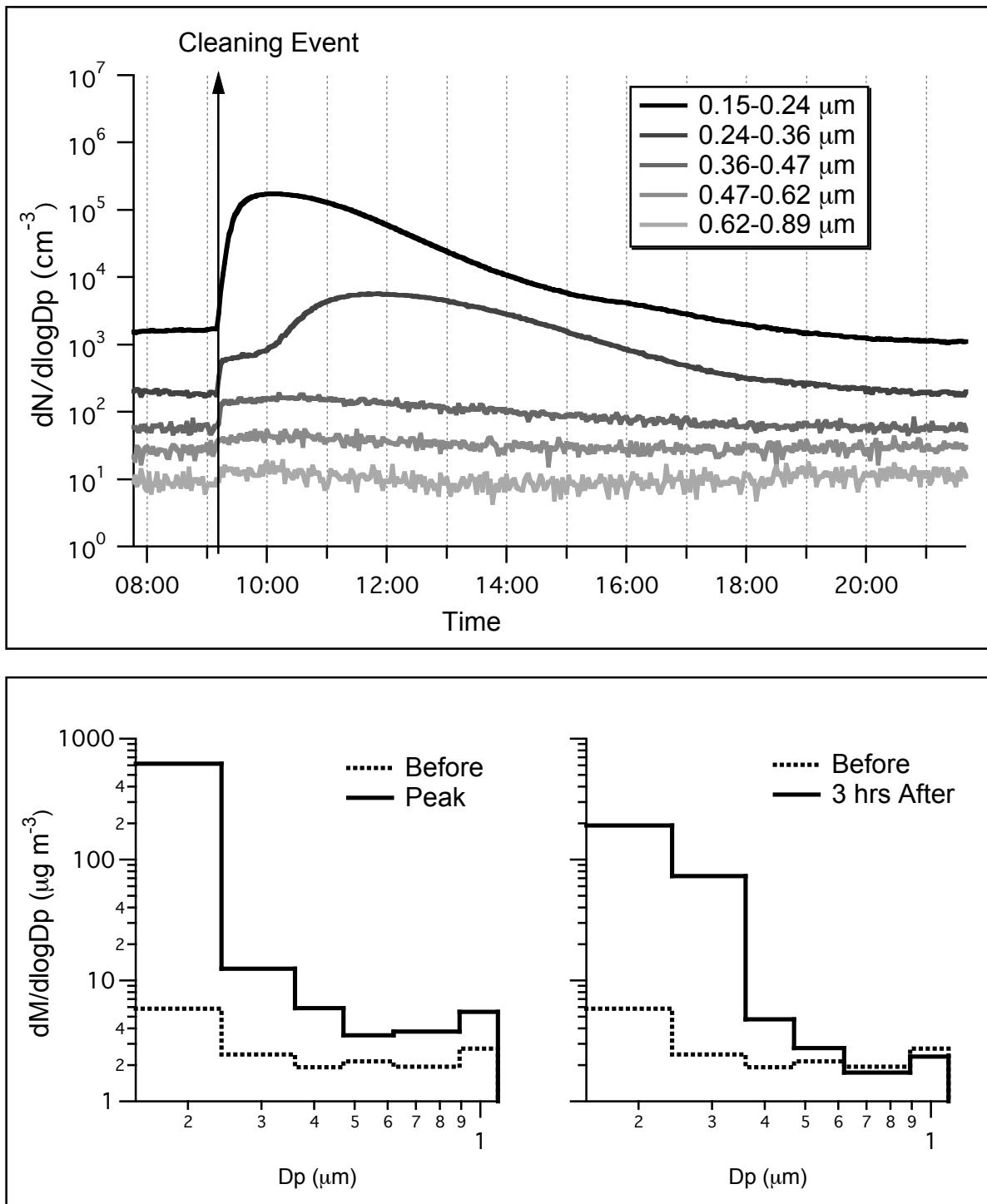
**Figure E.4.** OPC measurements of aerosol particles during Expt 3D (GPC-1, no ozone).



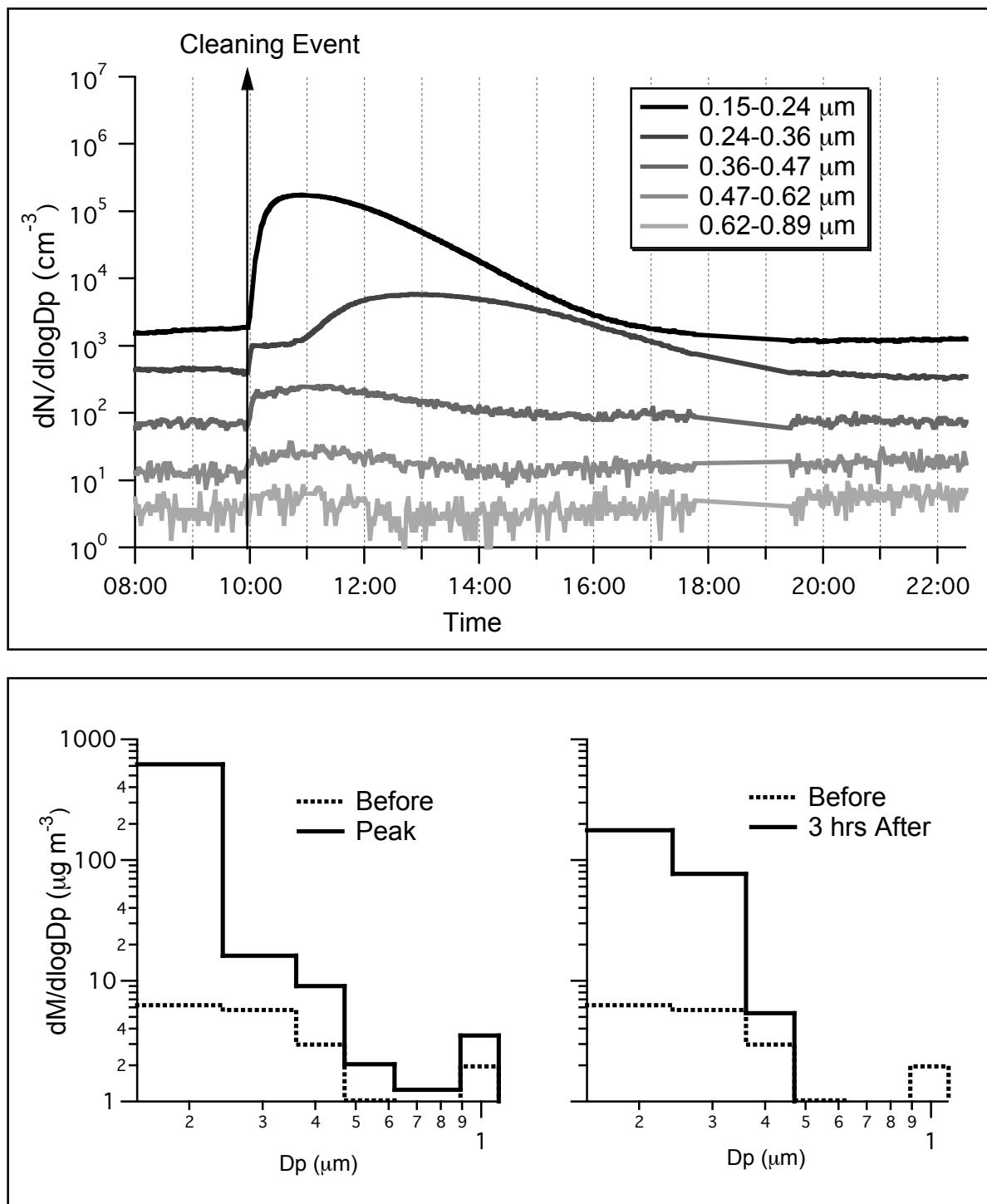
**Figure E.5.** OPC measurements of aerosol particles during Expt 3E (GPC-1, no ozone).



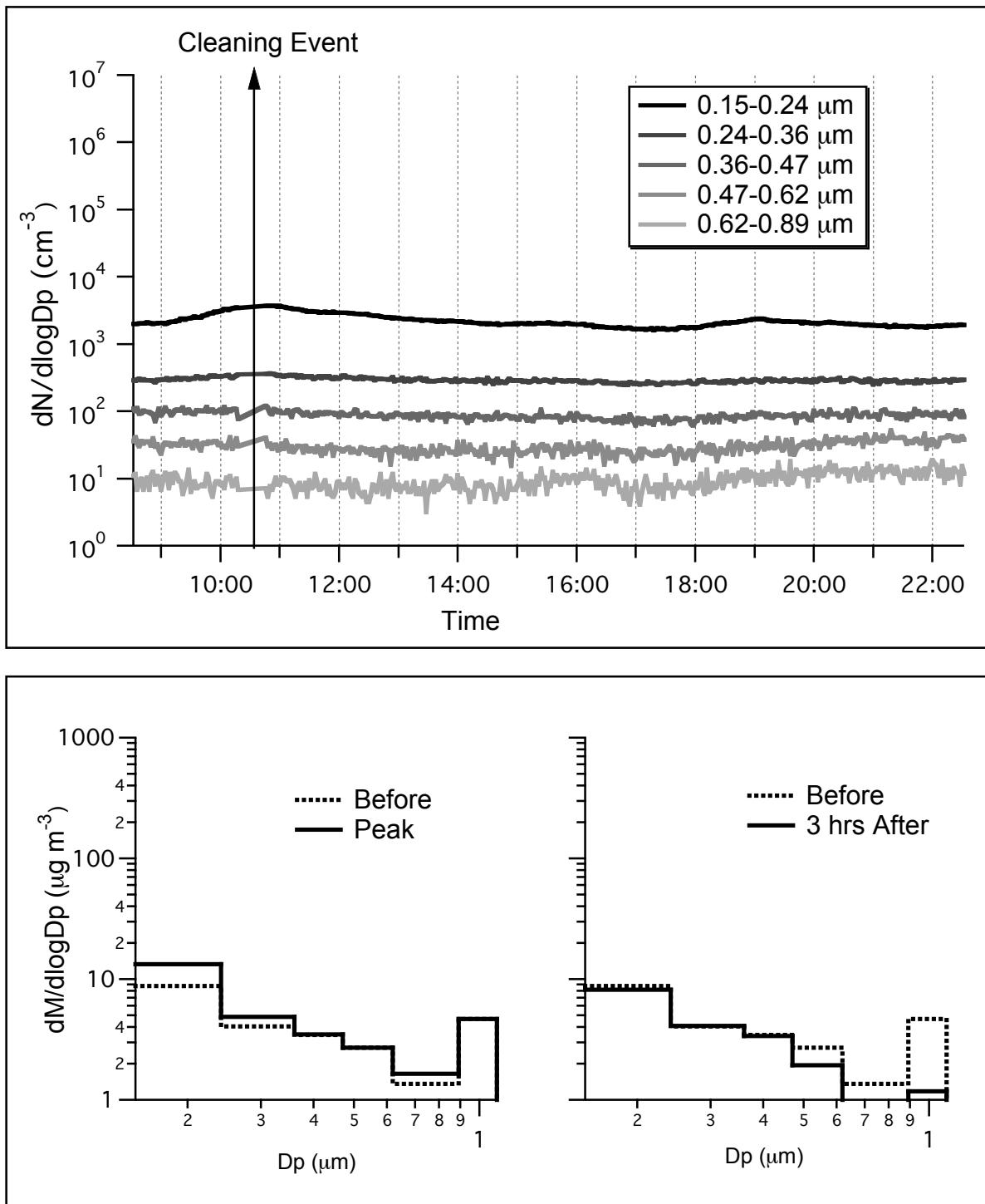
**Figure E.6.** OPC measurements of aerosol particles during Expt 3F (GPC-1, with ozone).



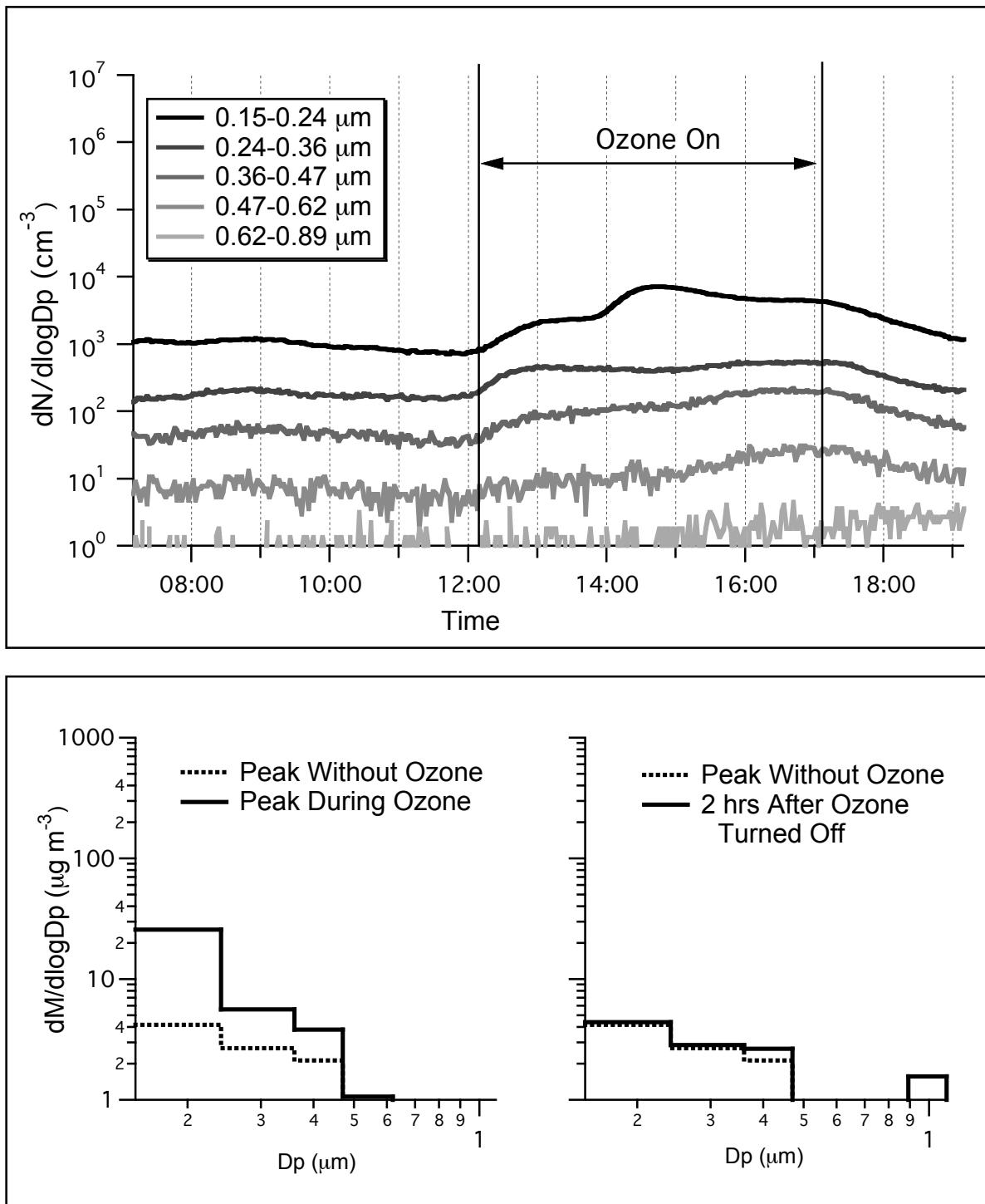
**Figure E.7.** OPC measurements of aerosol particles during Expt 3G (GPC-1, with ozone).



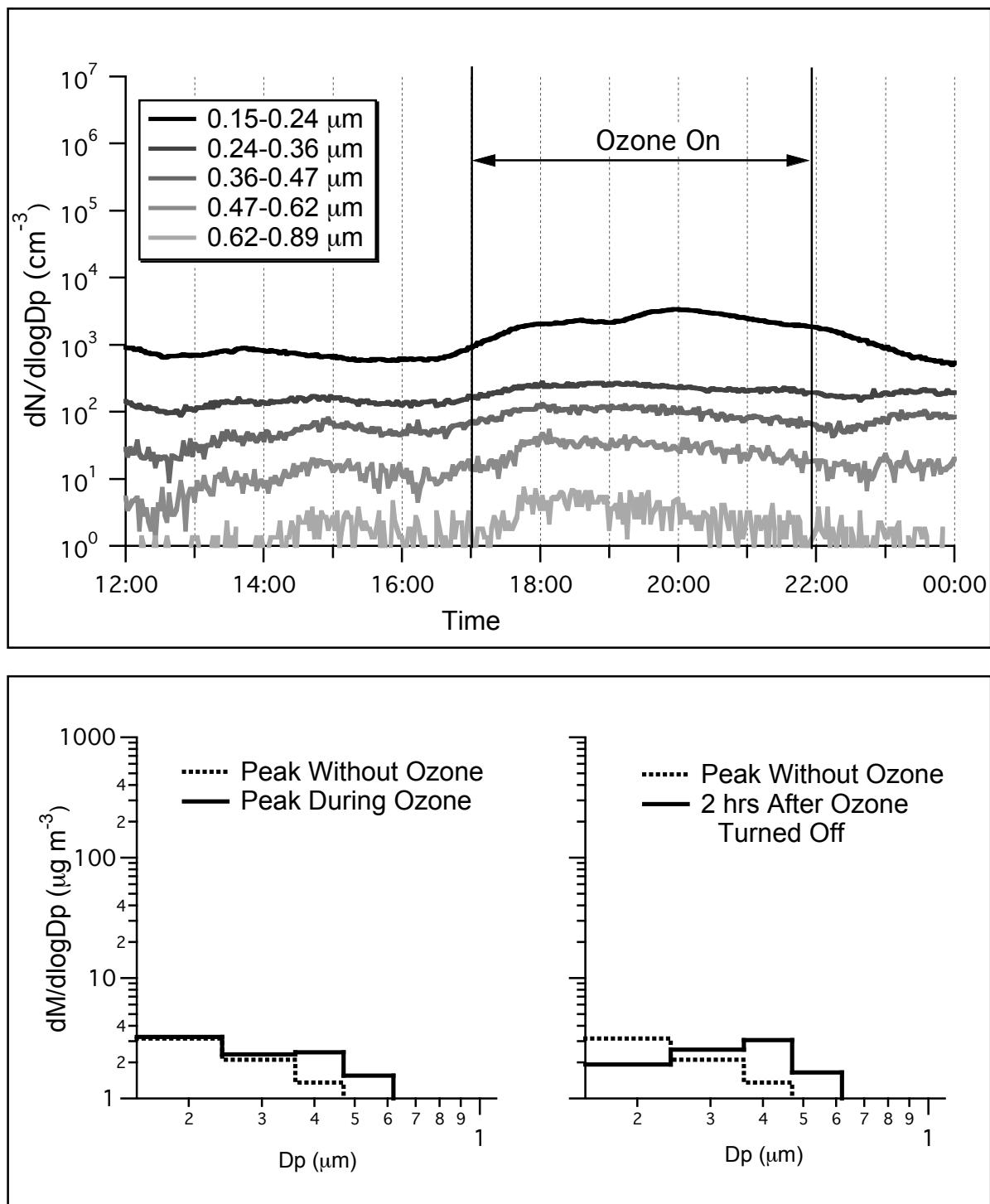
**Figure E.8.** OPC measurements of aerosol particles during Expt 3H (GPC-1, with ozone).



**Figure E.9.** OPC measurements of aerosol particles during Expt 3I (water mopping, with ozone).



**Figure E.10.** OPC measurements of aerosol particles during Expt 3J (AFR-1 at setting 1).



**Figure E.11.** OPC measurements of aerosol particles during Expt 3K (AFR-1 at setting 3).

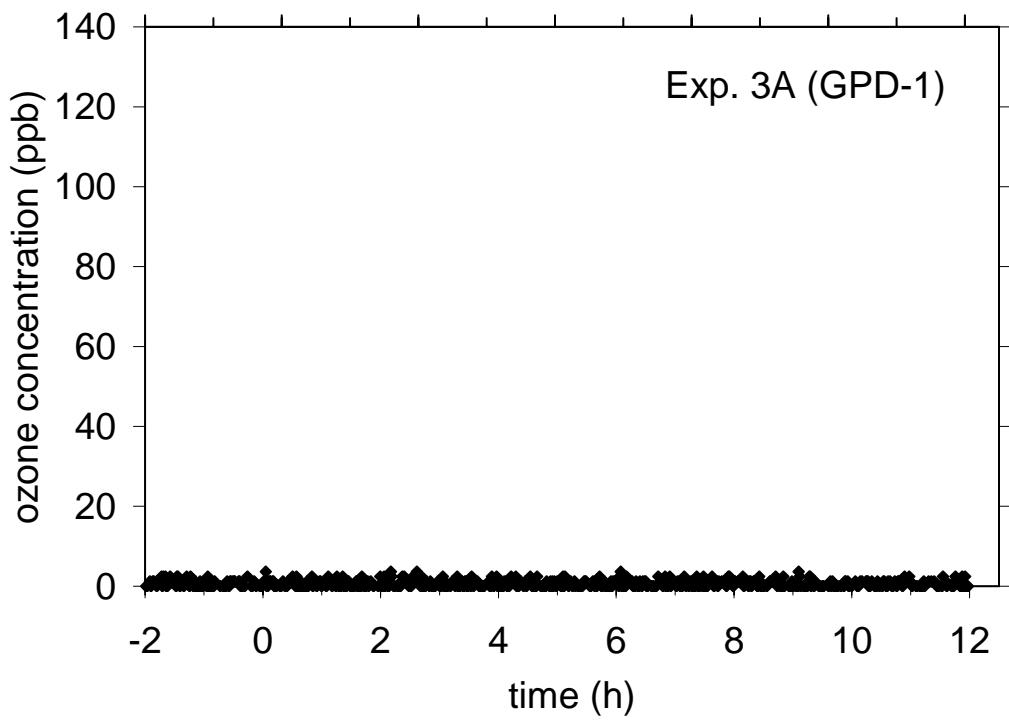


Figure E.12. Response of ozone analyzer in experiment 3A (no ozone in supply air).

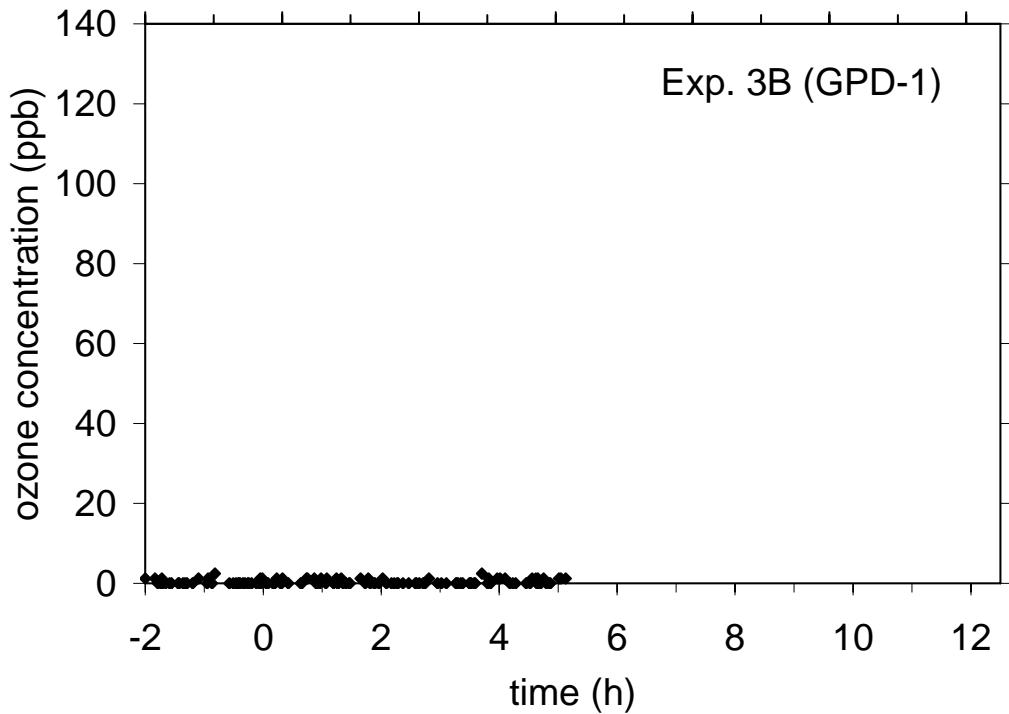


Figure E.13. Response of ozone analyzer in experiment 3B (no ozone in supply air).

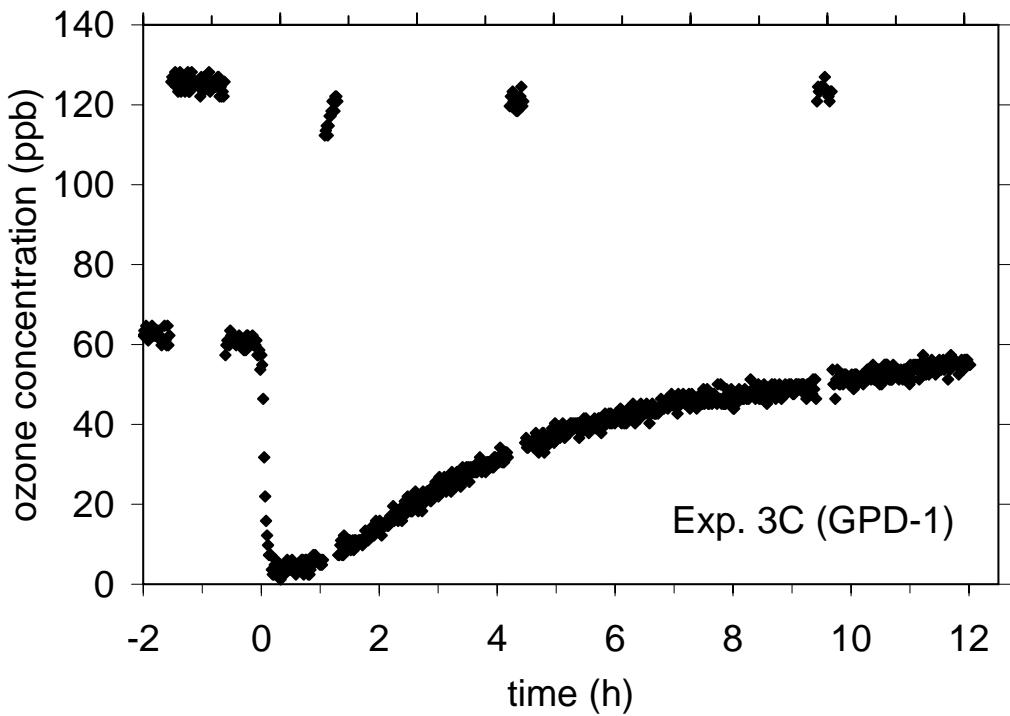


Figure E.14. Response of ozone analyzer in experiment 3C (ozone in supply air).

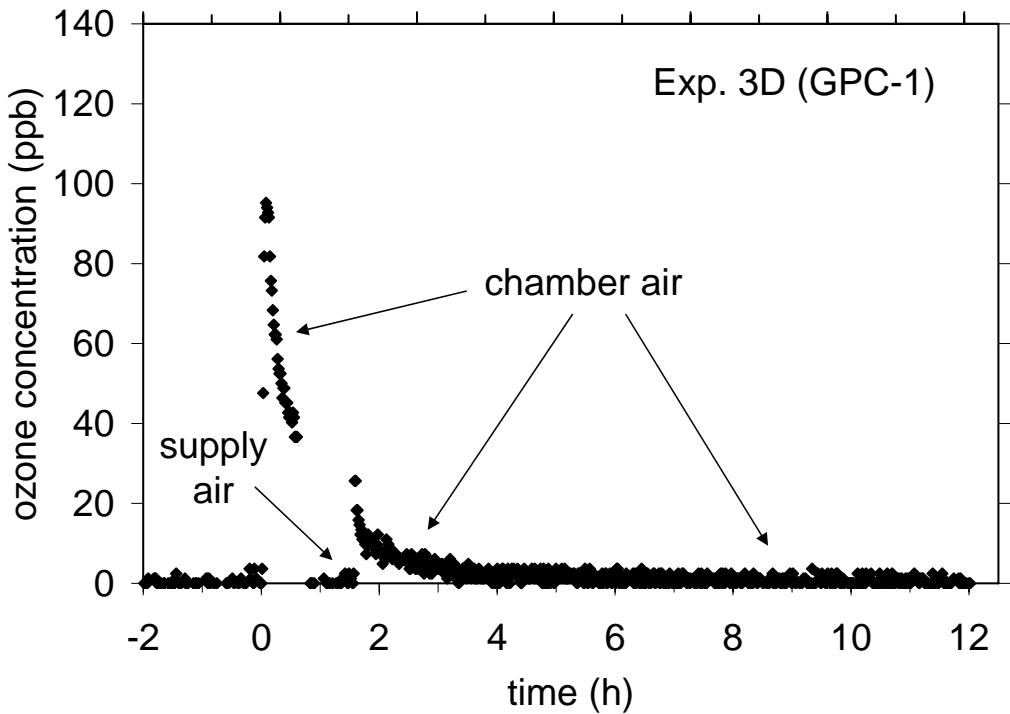


Figure E.15. Response of ozone analyzer in experiment 3D (no ozone in supply air).

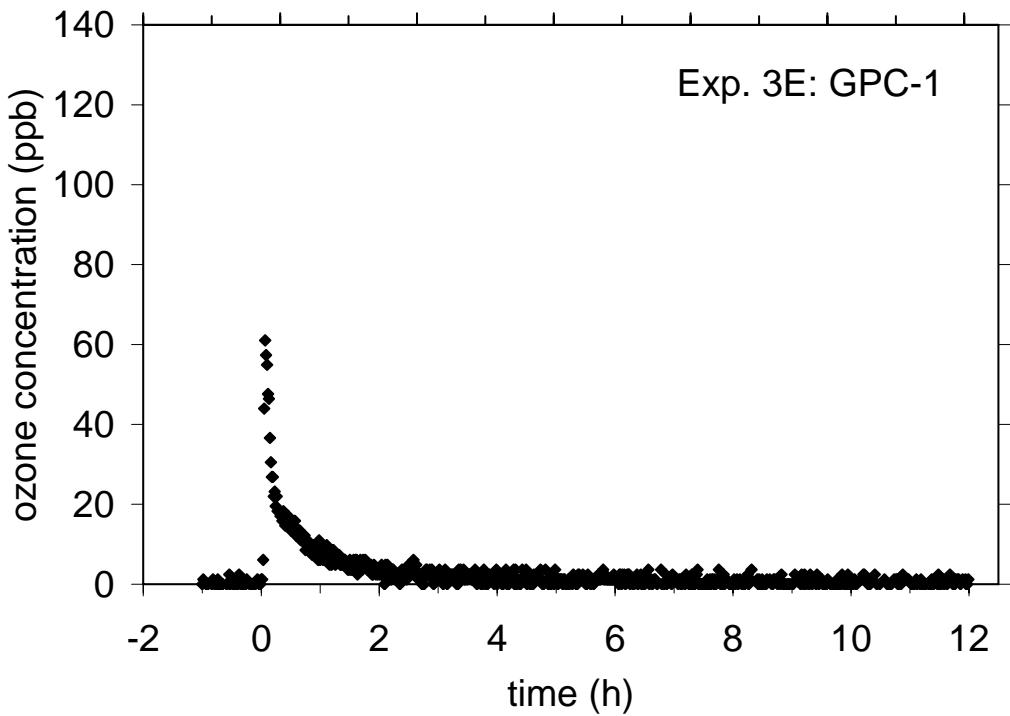


Figure E.16. Response of ozone analyzer in experiment 3E (no ozone in supply air).

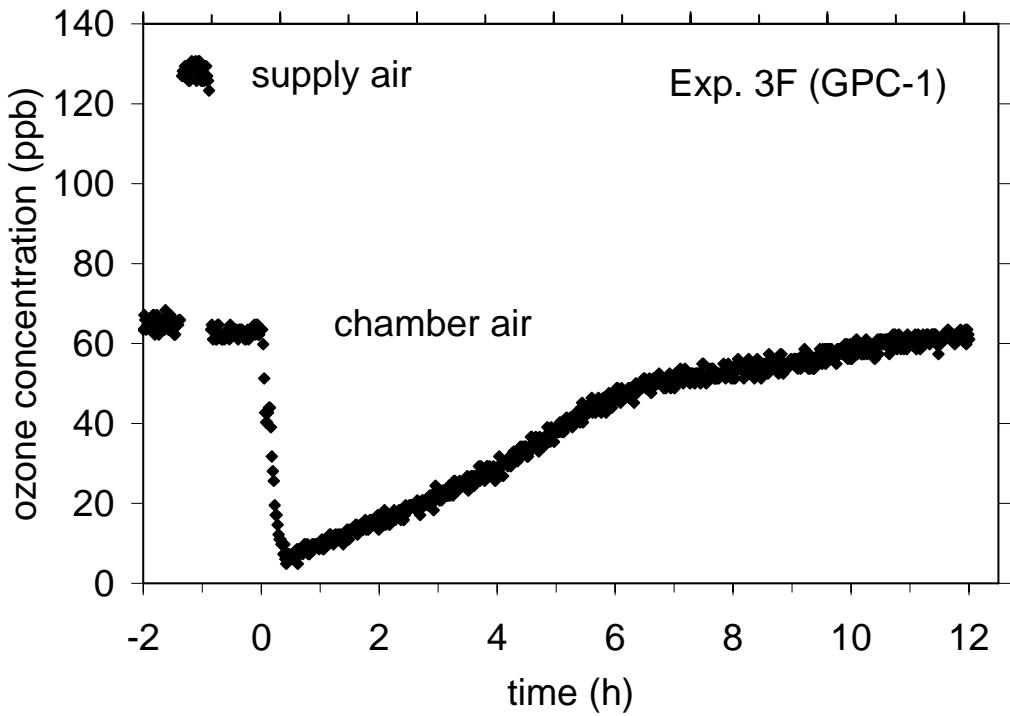


Figure E.17. Response of ozone analyzer in experiment 3F (ozone in supply air).

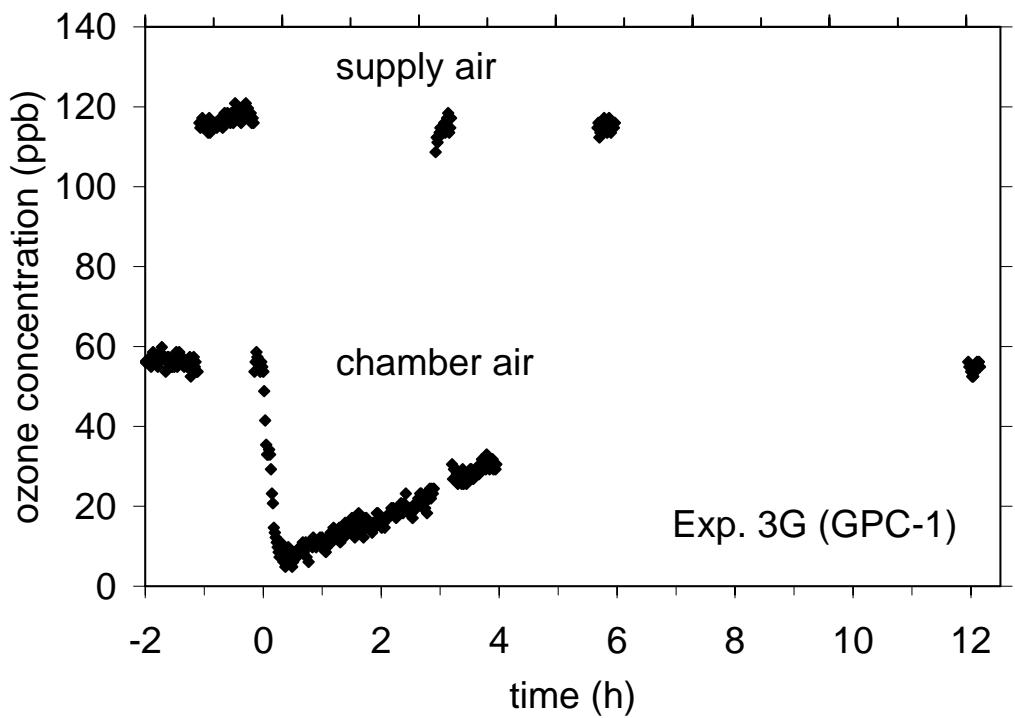


Figure E.18. Response of ozone analyzer in experiment 3G (ozone in supply air).

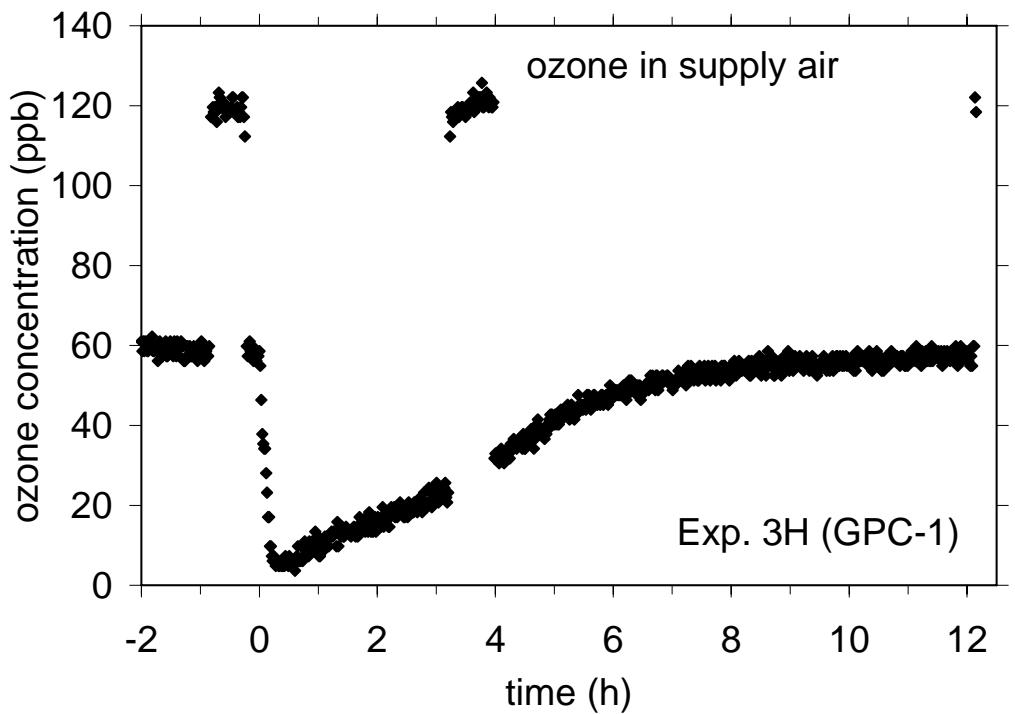


Figure E.19. Response of ozone analyzer in experiment 3H (ozone in supply air).

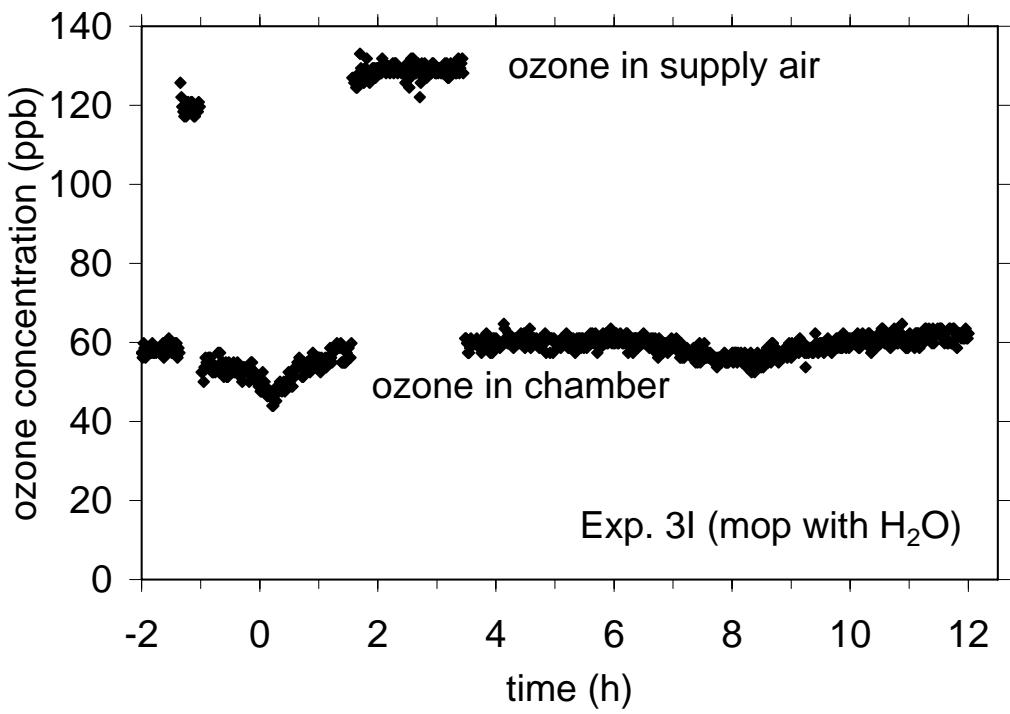


Figure E.20. Response of ozone analyzer in experiment 3I (ozone in supply air).

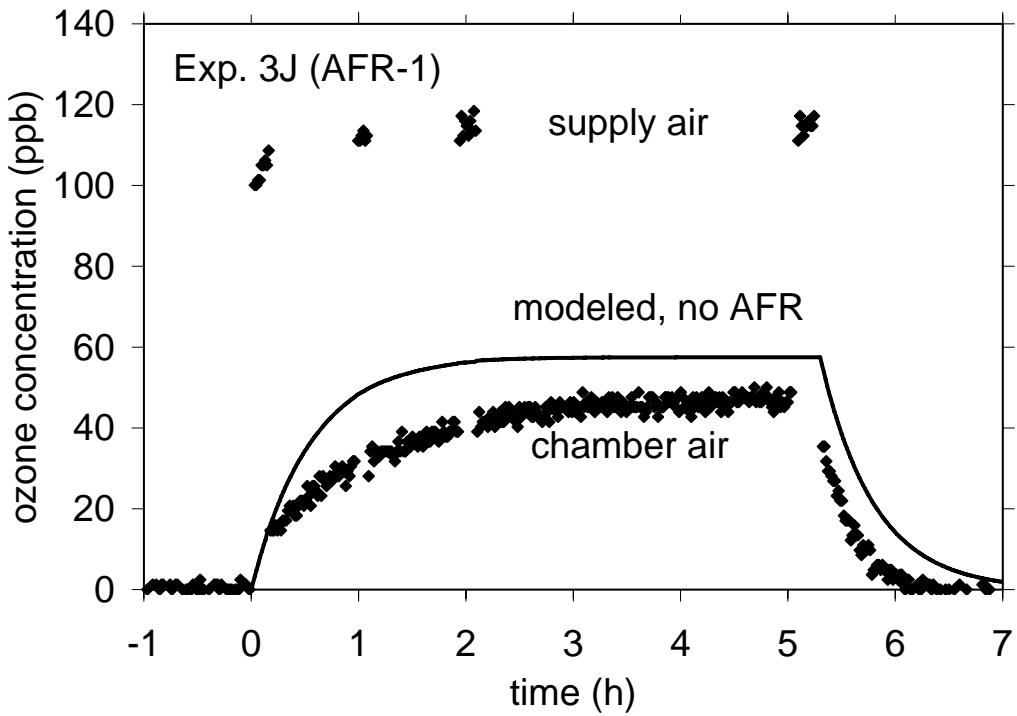


Figure E.21. Response of ozone analyzer in experiment 3J (ozone in supply air starting at t=0).

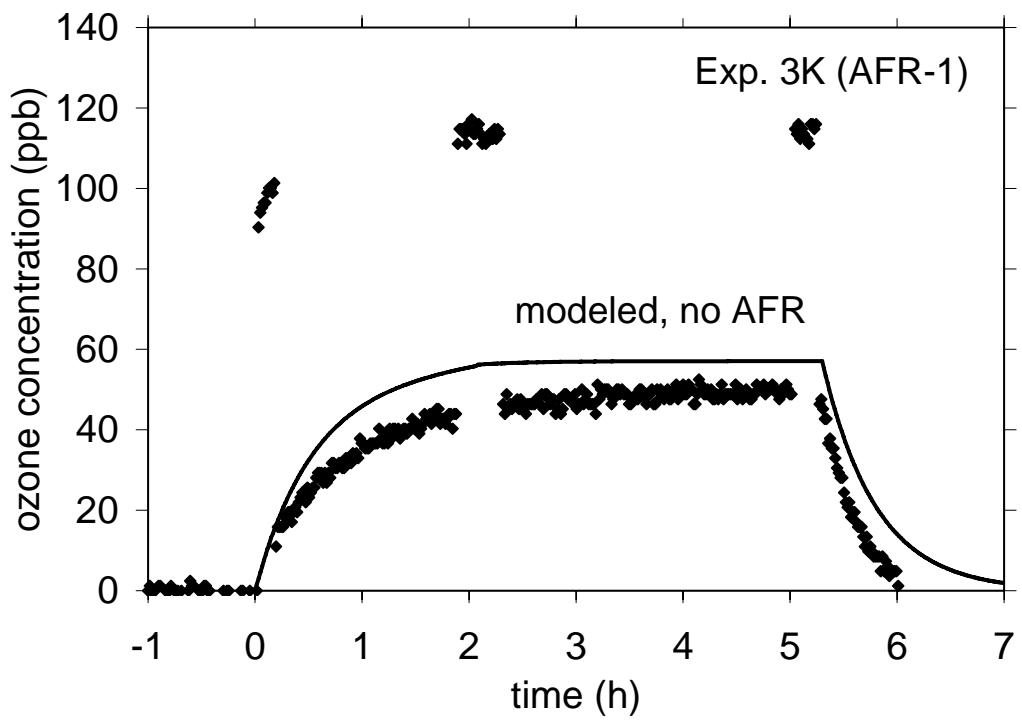
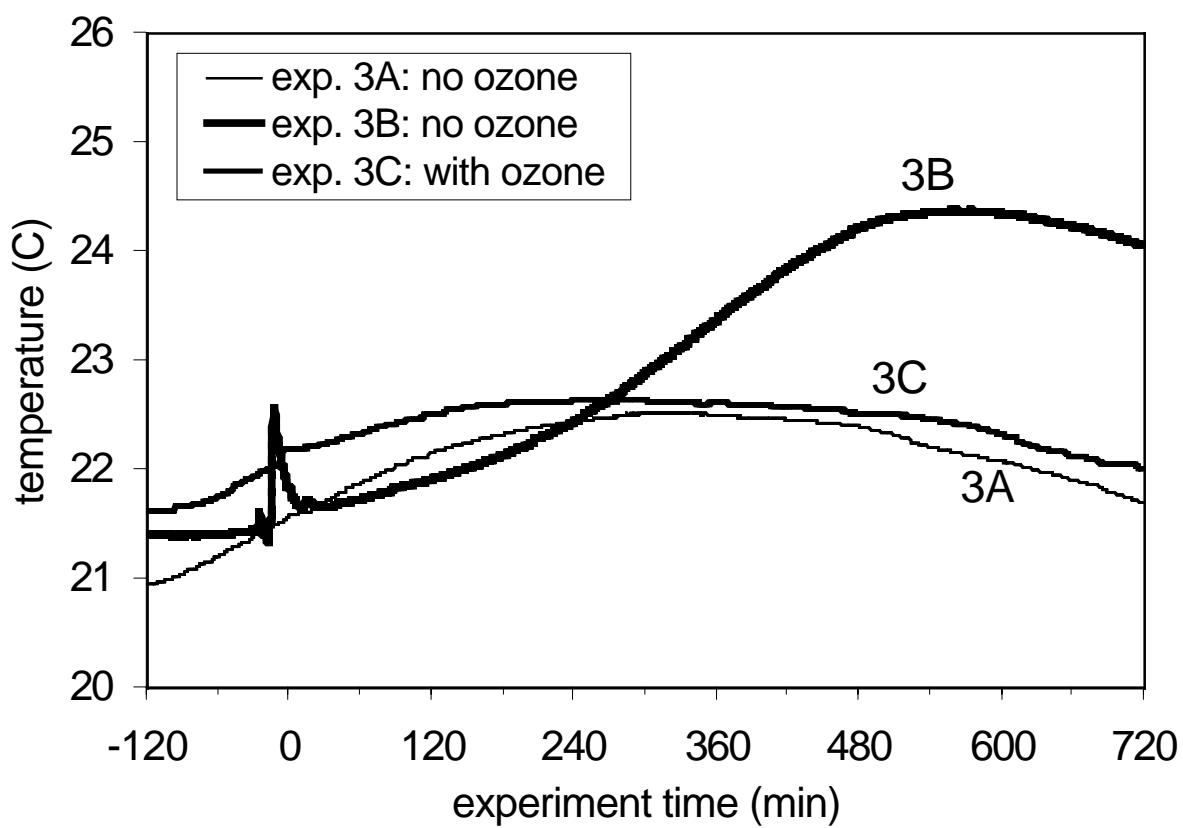
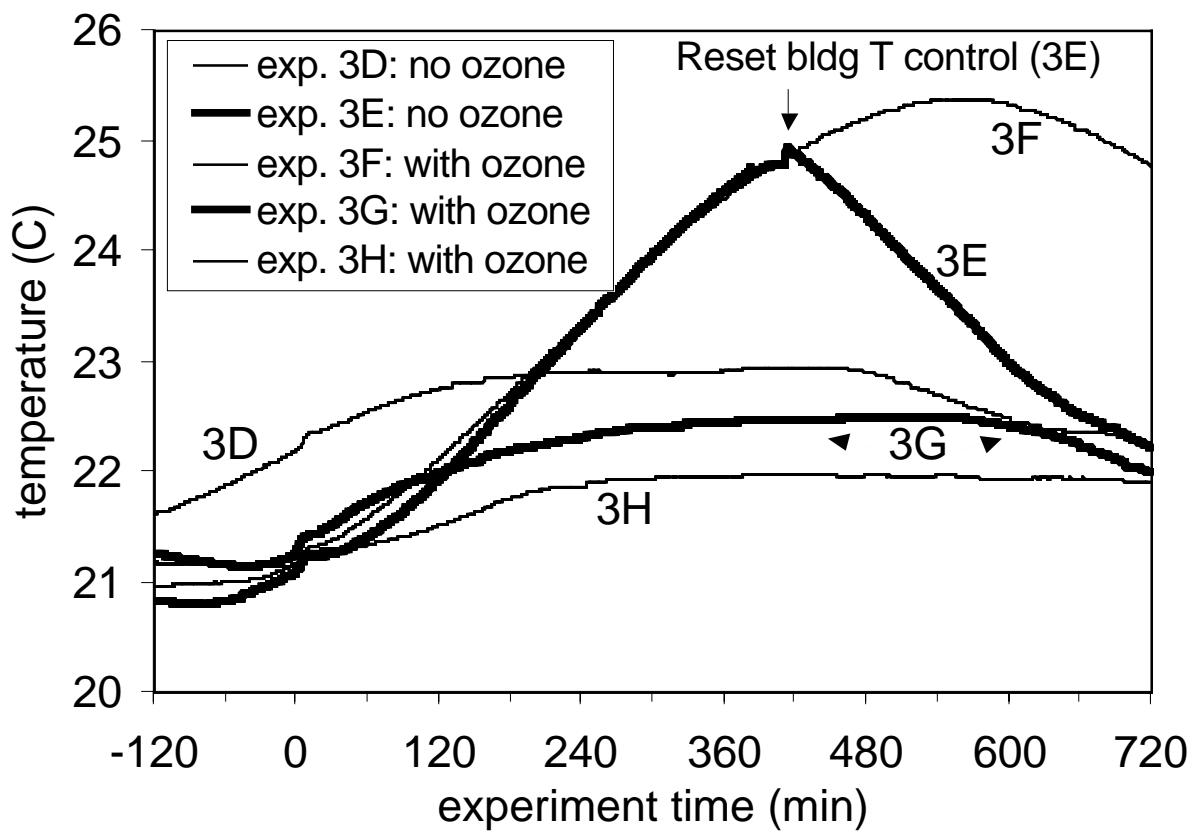


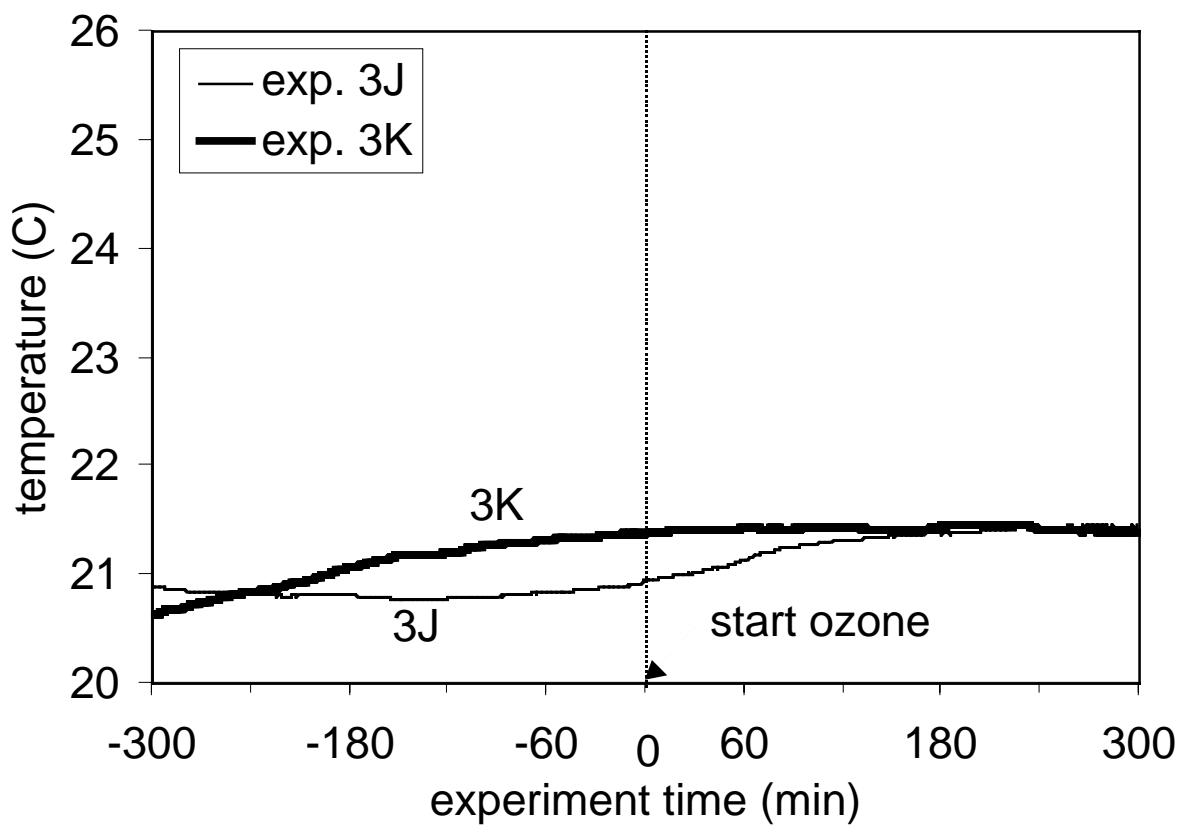
Figure E.22. Response of ozone analyzer in experiment 3K (ozone in supply air starting at t=0).



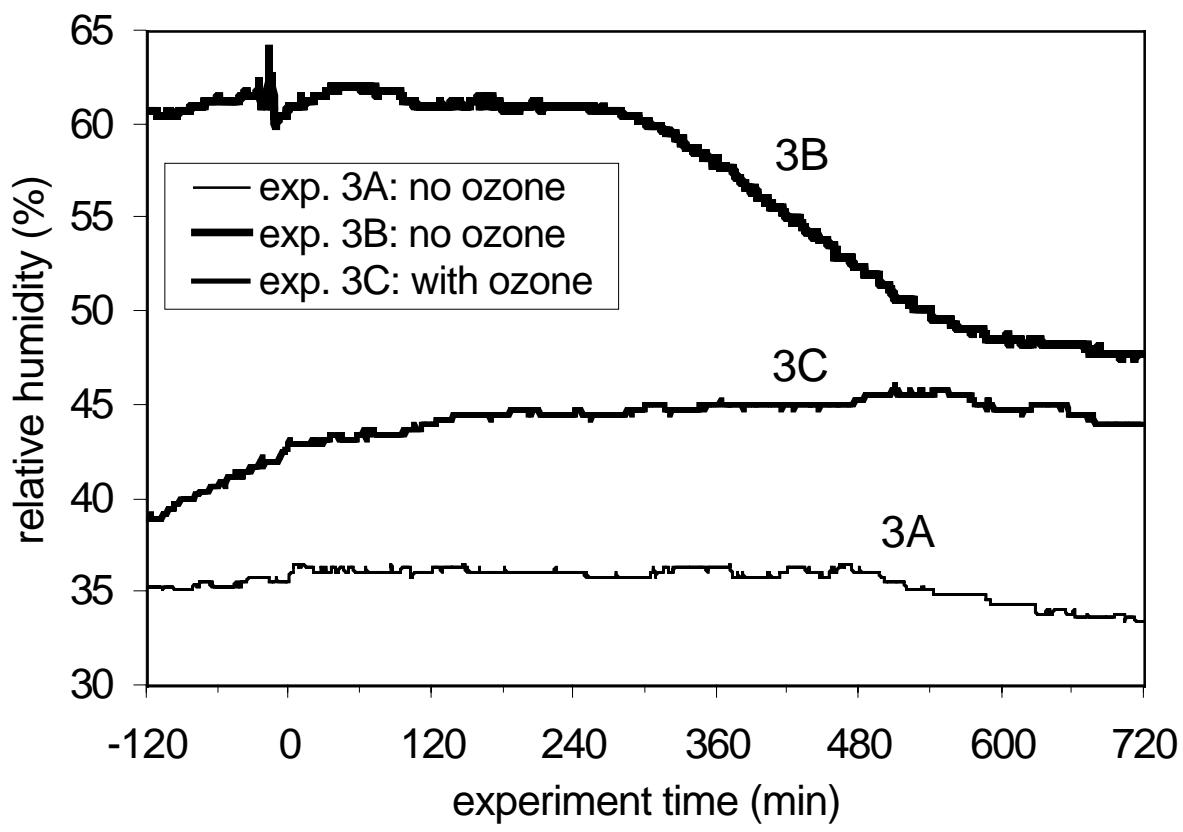
**Figure E.23.** Chamber air temperature versus time in experiments 3A, 3B, and 3C.



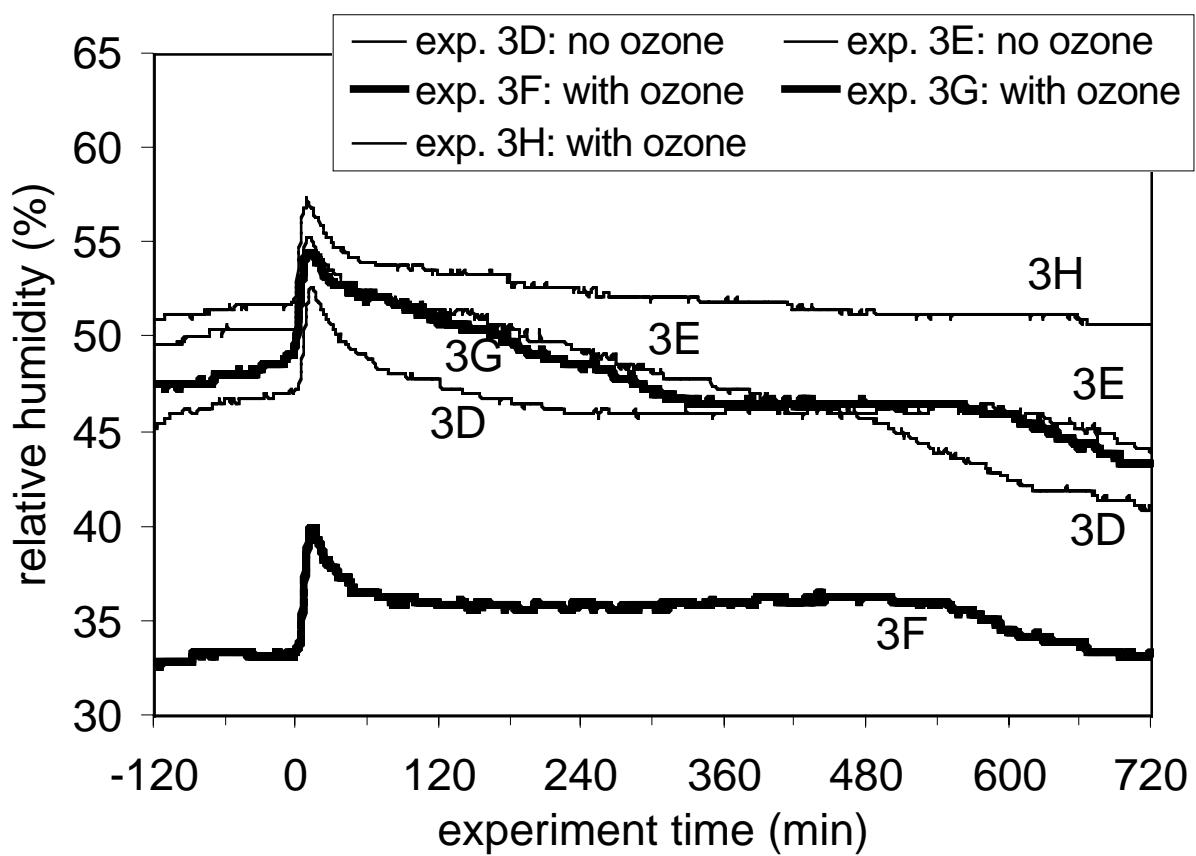
**Figure E.24.** Chamber air temperature versus time in experiments 3D, 3E, 3F, 3G, and 3H.



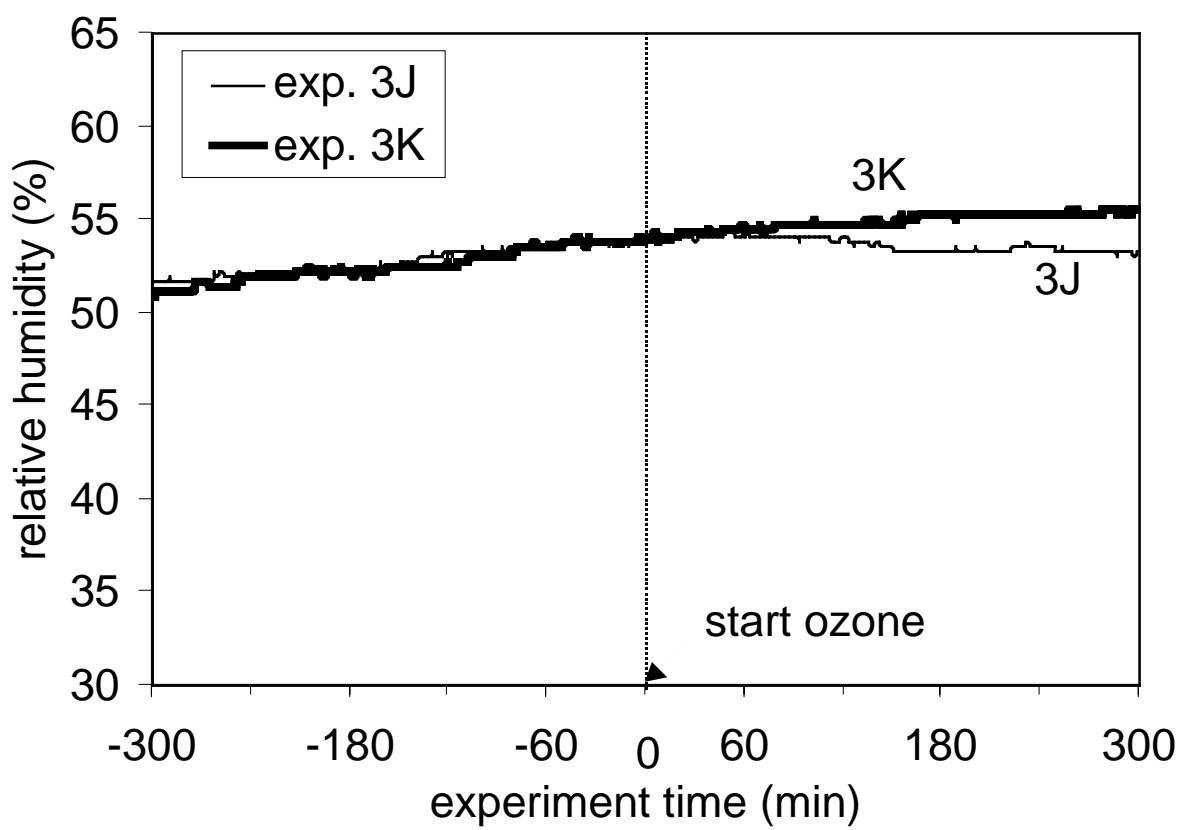
**Figure E.25.** Chamber air temperature versus time in experiments 3J and 3K.



**Figure E.26.** Chamber relative humidity versus time in experiments 3A, 3B, and 3C.



**Figure E.27.** Chamber relative humidity versus time in experiments 3D, 3E, 3F, 3G, and 3H.



**Figure E.28.** Chamber relative humidity versus time in experiments 3J and 3K.